# 4 Environmental Consequences




2012

US Army Corps
of Engineers
Galveston District

# Contents

# 4.0 ENVIRONMENTAL CONSEQUENCES

The City Houston (Houston), acting by and through its agent, the Coastal Water Authority (Applicant), has applied for a Department of the Army (DA) permit pursuant to Section 404 of the Clean Water Act from the U.S. Army Corps of Engineers (USACE), Southwest Galveston District (SWG) to authorize placing fill material in jurisdictional waters of the United States, including wetlands. The fill material would be used to construct a proposed water supply project needed to develop additional water supplies. USACE, Galveston District has determined an analysis on the significant natural and human environmental effects from the proposed Luce Bayou Interbasin Transfer Project (LBITP) and reasonable range of alternatives is necessary to provide for full public disclosure and to aid in decision-making.

The proposed action alternatives including the Applicant's preferred alternative would result in direct impacts to waters of the United States including wetland. These actions require authorization under the Clean Water Act, Section 404.

This Environmental Impact Statement (EIS) was prepared in accordance with the National Environmental Policy Act (NEPA) of 1969, as amended, and Corps of Engineers regulations for implementing NEPA (33 Code of Federal Regulations [CFR] 325, **Appendix B**). This EIS has also been formulated to address the information requirements of the Section 404(b)(1) Guidelines (40 CFR 230). USACE is the lead federal agency responsible for preparing the EIS. USACE has been assisted by a team of third-party contractors working under their direction in accordance with December 17, 1997 guidance from the Chief of Engineers regarding preparing an EIS. Information contained in the EIS serves as the basis for a decision regarding issuance of a Section 404 permit and provides information for local and state agencies having jurisdictional responsibility for affected resources.

This chapter addresses the environmental consequences of the implementation of the proposed project and alternatives to the LBITP that would transfer 450 million gallons per day (MGD) of water under gravity in compliance with an existing water rights permit from the Trinity River to Lake Houston for municipal use. This study focuses mainly on the direct environmental consequences for the area of Liberty County and eastern and northern Harris County, Texas as a result of the three proposed action alternatives described by **Chapter 2.5**, and the No Action Alternative described by **Chapter 2.3** of this DEIS:

- Alternative 1—No Action
- Alternative 3A—Applicant's preferred alternative, pipeline and canal conveyance of water to Lake Houston from a proposed pump station located on the Trinity River at Capers Ridge
- Alternative 4—Pipeline only alternative, conveyance of water to Lake Houston through dual 108-inch diameter pipelines under pressure from a proposed pump station located on the Trinity River at Capers Ridge
- Alternative 4—Pipeline only alternative, conveyance of water to Lake Houston through dual 108-inch diameter pipelines under pressure from the existing Trinity River pump station operated by the Coastal Water Authority located in Dayton, Texas

**Section 4.1** provides a summary of the number of acres of potential disturbance from the construction of facilities and infrastructure associated with each action alternative. The acres of disturbance have been calculated for Alternative 3A (Applicant's preferred alternative) and totals approximately 1,105 acres of land. This alternative includes construction and operation of the proposed 90-acre Capers Ridge Pump Station (CRPS), provision of an electrical power supply to CRPS, approximate three-mile long pipeline, sedimentation basin, approximate 18.5-mile long conveyance canal installed within a 300-foot right-of-way (ROW), 10-acre maintenance facility, and the proposed discharge structure that would outfall to Luce Bayou near the confluence with Lake Houston. The acres of disturbance have been calculated for Alternative 4 (975 acres) and includes transfer pumps and associated facilities/structures needed for a 24-mile long pipeline system to be installed within a 300-foot ROW and a 10-acre maintenance facility; Alternative 4 project elements include dual, 108-inch diameter pipelines that would convey 450 MGD of water in compliance with an existing water rights permit under pressure in two below-grade, steel pipes from the proposed approximate 90-acre CRPS to a discharge location at Lake Houston. The acres of disturbance have also been calculated for Alternative 6 (725 acres) and includes transfer pumps and associated facilities/structures needed for an approximate 20-mile long pipeline system to be installed within a 300-foot ROW; Alternative 6 project elements include dual, 108-inch diameter pipelines that would convey 450 MGD of water in compliance with an existing water rights permit under pressure in two below-grade, steel pipes from the existing Coastal Water Authority Trinity River Pump Station (TRPS) in Dayton, Texas to a discharge location at Lake Houston. The existing TRPS was expanded in 2010 and there are six pump bays to withdraw an additional 450 MGD from the Trinity River. New higher capacity pumps would need to be installed at the TRPS to effectively manage the withdrawal of an additional 450 MGD of water from that location. The direct and indirect effects of the proposed action would be generated by the following activities.

- Clear, grade (site preparation) and remove surface cover prior to excavating or constructing structures or facilities at property totaling a maximum of 1,200 acres that would be owned or under the control of the Applicant.

- Excavate, trench, backfill and dewater the construction areas including controlling surface water runoff during land preparation and installation of cofferdams along the Trinity River during CRPS construction.

- Implement traffic control measures during construction to minimize disturbance to area residents.

- Perform soil stability testing and engineering analyses to determine the need for support structures at the pump intake and discharge facilities, to facilitate the design for the sedimentation basin, canal conveyance, and the CRPS.

- Use of dozers and other earth-moving equipment to construct pipelines, canals, side berms, access or service road and drainage ditch construction;

- Construct coffer dams using sheet piles within the Trinity River and possibly Lake Houston during the proposed CRPS and Lake Houston discharge structure installation.

- Construct the equipment and facility maintenance building, access road, update existing TRPS or construct proposed pump station control facilities, update or install supervisory control and data acquisition (SCADA) system, maintain existing former residence at the CRPS entrance.

- Construct the 100-foot wide earthen canal with parallel maintenance roads and side-berms, water control structures and gates, and structural foundations or supports including the discharge box culverts.

- Install or re-route/extend utility lines, utility towers, oil or gas wells, and supply electrical power for operating the CRPS and for maintaining adequate water pressure within the pipeline installed as part of Alternative 4 and Alternative 6.

- Install dual 108-inch (9-foot) diameter pipelines in excavations such that the area of disturbance is a raised mound with access roads within the proposed 300-foot ROW; maintain security fencing and signage.

- Install, operate and maintain approximately 18 below-grade siphon structures to maintain the local hydrologic flow regime along the Alternative 3A conveyance canal and maintain security fencing and signage.

- Repair or replace residential, farm and other agriculture-related infrastructure (water wells, cell towers, irrigation ditches, canals, pumps, flow meters, etc.) that could not be avoided.
- Ship and truck construction materials to the site; stockpile materials and excavated soils; machine or fabricate materials; handle construction and demolition waste and related byproducts; handle and manage special and hazardous wastes.
- Store and stockpile construction-related materials and equipment (e.g., excavated soil, steel pipes, concrete, piping and fencing, steel supports and beams, electrical wiring, dry wall materials, floor tiles and related building supplies).
- Routine maintenance to include pipeline pigging operations on a periodic basis at the TRPS and the proposed CRPS for two, 108-inch (9-foot) diameter pipelines and pump station to maintain water flow.
- Withdraw water from the lower Trinity River in the amount of 230 MGD through 2025 and 450 MGD after 2025.
- Remove aquatic vegetation including invasive plant species such as giant salvinia, as needed, from the canal to maintain desired water flow.
- Repair and maintain an approximate 3-mile-long pipeline and 18.5-mile long canal conveyance (Alternative 3A) including reconstructing side slopes with minor slumps and cracks, and maintaining the water flow structures, siphons, fencing, roads, flow gates and ancillary equipment.
- Repair and maintain the approximate 24-mile-long pipeline (Alternative 4) and the approximate 20-mile long pipeline conveyance structure and pumping/electrical facilities including those needed to maintain flow—maintain the existing TRPS, SCADA system, pump bays, six pumps, ancillary structures, siphons, fences, access roads, sedimentation basins, flumes, flow gates/stations, maintenance buildings, and associated necessary equipment.
- Store and manage appropriately the sediment removed from the Trinity River onsite and at the sedimentation basin.
- Provide sanitary and solid waste management, storm water and pollution prevention planning, and water and wastewater disposal; control construction noise and dust at the proposed CRPS discharge location and the proposed equipment maintenance building.
- Coordinate travel time and distance between construction worker residences, pump station operators' residences, facility maintenance workers, construction work sites and the location of long-term job sites including the CRPS, canal or siphon structures, pipeline excavation areas, and the proposed maintenance facilities.
- Cleanup, site restoration, mitigation of unavoidable effects to aquatic and other resources including erosion protection at the outfall and intake structures in compliance with applicable federal and state regulations and guidelines and specific requirements of necessary project permits.

The focus of the environmental impact evaluation is to compare how each of the alternatives affects each of the resources. The environmental impacts evaluation includes a wide range of resources including water quality, recreation, wildlife, sensitive species, aquatic resources, vegetation, wetlands, socioeconomics, and cultural resources. The methods for the evaluation vary depending on the resource and include quantitative and qualitative assessments. For example, water quality is addressed quantitatively with the use of models to predict changes in water quality that would result from the interbasin transfer of water to Lake Houston, while the effect on recreational users of Lake Houston or the Trinity River may be addressed qualitatively. The area with potential direct effects for physical and biological resources, such as topography, soils, air quality, water resources, and floodplains, is the immediate vicinity of the project right-of-way (ROW) in areas that clearing, grading, excavation, construction, and dewatering would occur and the proposed mitigation property (**Chapter 6**). The potential impact area for socioeconomic resources is generally described on a regional basis as the Houston metropolitan area and represents the TWDB's Region H water planning boundaries (**Figure 4-1**).

A variety of tools were used to assess potential environmental consequences of the action and No Action alternatives. Geographical information system (GIS) was used to combine a base map of the area with data sets representing resources such as soil types, vegetation/habitat types, and wetlands to determine the acreages affected under existing conditions and under each of the alternatives. To determine the behavior of sedimentation at the proposed pump station or discharge structure, hydrodynamic geomorphology modeling was performed. Hydrology is a key parameter for the evaluation of environmental and instream flow requirements. Water level fluctuations based on flow data obtained at established monitoring stations illustrate existing flows and projected low and high flow scenarios under various regulatory scenarios developed to meet requirements of Senate Bill 3. These and similar graphical illustrations provide an understanding of the effects of the proposed project on environmental flow requirements. The discussions provided in this chapter on environmental consequences also provide greater detail about the specific methodologies used to assess impacts on each resource.

Operations for the proposed action alternatives would include pipeline and canal maintenance such as repair, nuisance and exotic aquatic species removal, maintaining and mowing the canal berms, pipeline pigging, and sediment management. An approximate 3,000-acre property owned by the Applicant is proposed for mitigation for unavoidable impacts to aquatic species for the implementation of Alternative 3A, Alternative 4 or Alternative 6. Facilities constructed or installed within the boundaries of the mitigation property to be conveyed to the Trinity River National Wildlife Refuge (TRNWR) include dual 108-inch (9-foot) diameter below-ground pipelines, pipeline or CPRS maintenance or access roads, electrical power distribution system, a sedimentation basin and sediment storage area, and the beginning of the canal section (Alternative 3A) that adjoins the sedimentation basin within the proposed 300-foot canal ROW. For Alternative 4, the facilities within the proposed mitigation property would include dual 108-inch (9-foot) diameter below-ground steel pipes, electrical power distribution system, and maintenance or access roads. Facilities constructed to implement Alternative 3A or Alternative 4 within property conveyed to the TRNWR would be owned by the Applicant. These facilities would be fenced and locked with warning signs while access would be denied to the public and USFWS staff. There would be designated crossings to provide access to the proposed mitigation site for the public and USFWS staff after property transfer to the TRNWR. In addition, it is likely that oil and gas drill locations would be established by the USFWS within the mitigation property as needed to meet the obligations to the owners of the mineral rights. As planned, the USFWS would manage the mitigation property along the Trinity River and the Applicant would not incur further mitigation or monitoring responsibilities associated with proposed project permitting.

The magnitude, duration and intensity of potential environmental consequences of the proposed action alternatives and No Action are based on a comparison to regulatory standards, criteria, Executive Orders, and laws, best available data analysis, scientific documentation, and professional judgment applied to the analysis by resource specialists. Mitigation or modification measures may be identified in this chapter to manage or reduce potentially adverse consequences. Other projects are expected to take place in the project vicinity regardless of which action or no alternative is implemented. These projects are included in the environmental analyses to ensure consideration of potential cumulative effects. These other projects would be completed at different times throughout the study period. The potential cumulative environmental effects from these past, present and reasonably foreseeable projects are presented in **Chapter 5** of this DEIS. Proposed project mitigation is presented in **Chapter 6**.

The No Action Alternative is considered by this study consistent with Council on Environmental Quality (CEQ) regulations implementing the National Environmental Policy Act (NEPA). The No Action Alternative is described in **Chapter 2.3** of this DEIS. The No Action Alternative assumes that the Applicant would not receive authorization under Section 404 of the Clean Water Act to fill approximately

203 acres of waters of the United States, including wetlands, in order to construct and implement the LBITP and that Houston would be unable to provide sufficient water to meet municipal water demand for the Houston extraterritorial jurisdiction (ETJ) from 2020 onward. No Action is the ‘no build’ alternative. Water supply strategies developed through regional water planning efforts initiated by the State of Texas, such as constructing the Allen’s Creek reservoir and additional interbasin transfers, were identified in the 2011 Region H Regional Water Plan (RWP) and area described as ‘needed’ to meet Houston area’s water demand through the planning horizon of 2060. The Region H RWP has considered a comprehensive set of measures to manage water supply.

The critical lack of additional available surface water in the San Jacinto River watershed is recognized by the Region H RWP. The conclusion reached through the consensus regional water planning process is that the interbasin water transfer from Lake Livingston to Lake Houston via the Trinity River is essential to meeting the forecasted demand even if the water supply or conservation (drought management) strategies are implemented.

USACE's decision will be to issue, issue with modification or deny the DA permit submitted by the Applicant for implementing the proposed action which is the proposed LBITP. As described by **Chapter 2** of this DEIS, the No Action Alternative is described for by three possible scenarios. All three scenarios are predicated on a No Action Alternative (‘no build’) that assumes the Applicant, as an agent for Houston, would not receive authorization under Section 404 of the Clean Water Act to fill approximately 203 acres of waters of the United States, including wetlands, to construct and implement the LBITP. Without the construction and implementation of the LBITP, Houston would not be able to meet their contracted demand allocations (projected long-term water supply requirements identified by the 2011 Region H Regional Water Plan (RWP) and the 2012 State Water Plan), and would not be able to meet mandated groundwater conversion to surface water supply sources to control area subsidence by the mandated conversion dates imposed by Harris-Galveston Subsidence District (HGSD) and the Fort Bend Subsidence District. The No Action Alternative would result in Houston being unable to use surface water to meet the Houston area needs starting in 2020. Lake Houston, the water supply reservoir on the San Jacinto River, east of Houston, would continue to supply surface water to Houston although by 2020 would not be able to meet projected water demand.

The first scenario described as a component of the LBITP No Action Alternative is summarized below:

- Under this alternative, future water demands would be through continued diversion from the Trinity River from the existing Trinity River Pump Station (TRPS) that would be expanded to accommodate the facilities and equipment necessary to provide for the increased withdrawals. Raw water would be conveyed from the TRPS to the existing East Water Purification Plant (EWPP) and Southeast Water Purification Plant (SEWPP) through existing conveyance facilities and through an underground pipeline to the Northeast Water Purification Plant (NEWPP) for treatment and distribution. The environmental consequences analyses of this No Action component are organized by resource topic and are identified as Action Alternative 6 and provided in the appropriate subsections of the LBITP DEIS **Chapter 4**.

The second scenario described as a component of the LBITP No Action Alternative is summarized below:

- With this No Action approach, Houston’s future increased water demands would be met by other regional alternatives for water supply and supplies would be provided from other sources rather than Lake Livingston. The Region H RWP includes water management strategies which could potentially reduce demands on NEWPP and Houston’s overall northeast and northwest service areas including such strategies as Allen’s Creek Reservoir, industrial wastewater reuse for the Houston Ship Channel area, desalinating coastal waters, and, as an alternative strategy, interbasin transfers for existing water supplies from East Texas. Except for interbasin transfers from existing East Texas supplies, Region H RWP provided data and analyses to demonstrate that these strategies would not provide water to meet the water need identified by the City of Houston and that the suggested effort would not result in a reliable water supply equivalent to available Trinity River supplies. The environmental consequences analyses of this No Action Alternative component are therefore organized by resource topic and are identified as the No Action Alternative (i.e., No Build Alternative) and provided in the appropriate subsections of LBITP DEIS **Chapter 4**.

The third scenario described as a component of the LBITP No Action Alternative is summarized below:

- Water demand would be managed to eliminate the need or delay the timing of the proposed LBITP. Under this scenario, construction and implementation of the LBITP would either not occur or would be delayed until some future time. The implementation of this scenario includes delaying the need for water within the NEWPP service area and also reducing the need for water by implementing aggressive water conservation measures or through substantial wastewater reuse programs. However, the environmental consequences analyses of this No Action Alternative component are organized by resource topic and are identified as the No Action Alternative (i.e., 'No Build' alternative) and provided in the appropriate subsections of this DEIS.

These strategies would involve fundamental changes to water supply, water management, subsidence control, conservation and drought management, and related programs involving hundreds of municipal utilities and would directly and indirectly affect millions of people.

Water supply strategies such as constructing the Allen's Creek reservoir and additional interbasin transfers were identified in the 2011 Region H RWP and area described as 'needed' to meet Houston area's water demand through the planning horizon of 2060. The Region H RWP has considered a comprehensive set of measures to manage water supply. The critical lack of additional available surface water in the San Jacinto River watershed is recognized by the Region H RWP. The conclusion reached through the consensus regional water planning process is transferring water from Lake Livingston to Lake Houston via the Trinity River is essential to meeting the forecast demand even if the water supply or conservation strategies are implemented.

The area with potential direct effects for physical and biological resources, such as topography, soils, air quality, water resources, and floodplains, is the immediate vicinity of the project ROW in areas that clearing, grading, excavation, construction, and dewatering would occur. The potential impact area for socioeconomic resources is generally described on a regional basis as the Houston metropolitan area and represents the TWDB's Region H water planning boundaries (**Figure 4-1**). The proposed LBITP would require the following:

- Constructing new facilities
- Implementing security and safety measures
- Managing sediment
- Pipeline, utility, stream, wildlife and roadway crossings
- Providing electrical power
- Acquiring property for public use
- Constructing drainage crossings, outfall and ancillary structures
- Mitigating unavoidable project effects including shoreline and river bank erosion protection
- Acquiring and managing public project funds

Construction activities may or could include the following:

- Property acquisition using Houston real estate purchase policies or evocating eminent domain
- Developing and issuing necessary permits and project authorizations
- Clearing and grubbing
- Establishing and using equipment laydown, staging and fueling areas within a permitted 300-foot ROW

- Grading and contouring the land surface
- Trenching and backfilling
- Hydrostatic testing of pipelines
- Earth moving to facilitate canal, berm, access or service road and drainage ditch construction
- Water body crossings with siphon structures, drainage features, and similar types of construction
- Road, pipeline and utility easement crossings
- Installing or restoring existing irrigation and drainage structures and agricultural pump or reservoirs
- Installing security fencing and signage
- Constructing a maintenance facility
- Traffic management during construction
- Cleanup, site restoration, mitigation and erosion protection at the outfall and intake structures in compliance with applicable federal and state regulations and guidelines and specific requirements of necessary project permits

Operations for the proposed LBITP would include canal maintenance such as repair, nuisance and exotic aquatic species removal from the canal, maintaining and mowing the canal berms, and sediment management. As planned, the USFWS would manage the mitigation property along the Trinity River and the Applicant would not incur further mitigation or monitoring responsibilities associated with Corps or other permitting. Facilities constructed or installed within the boundaries of the mitigation property to be conveyed to the Trinity River National Wildlife Refuge (TRNWR) property include the pipelines, the CRPS and pipeline maintenance access roads, sedimentation basin and sediment storage area, and the beginning of the canal section adjoining the sediment basin within the proposed 300-foot ROW. The proposed LBITP facilities encompassed within the TRNWR boundaries would be owned by the Applicant. These facilities would be fenced and locked with warning signs, and access would be denied to the public and USFWS staff. There would be designated crossings to provide access to the proposed mitigation site for the public and USFWS staff after property transfer to the TRNWR.

For purposes of the environmental consequences that would occur as a result of the Applicant's and the Corps' preferred action alternative, Alternative 3A, it is assumed all Applicant-owned equipment would not be operated simultaneously, and equipment needed for operating Alternative 3A would be stored at the proposed maintenance facility or at property currently owned or operated by the Applicant.

**Figure 4-1:
Existing and Recommended Water Supply Reservoirs
as Shown in the 2012 State Water Plan**


Base from ESRI Online accessed December 2011;
Existing and recommended reservoirs from TWDB.

**Figure 4-1 : Existing and Recommended Water Supply Reservoirs as shown in the 2012 State Water Plan**

**Luce Bayou Interbasin Transfer Project**

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For each impact category for which direct environmental consequences has been identified, the following information is generally provided for each resource category:

- Background and method description (i.e., possibly the regulatory context, the thresholds of significance, or the method used for effects analysis development)
- Alternative 1—No Action
- Alternative 3A—Impact assessment for Alternative 3A, Applicant's Preferred Alternative
- Alternative 4—Impact assessment for Alternative 4
- Alternative 6—Impact assessment for Alternative 6
- Identification of means to minimize effects or incorporate proposed mitigation measures

In addition to major components of the Applicant's preferred and identified action alternatives, other projects are expected to take place in the project vicinity regardless of which alternative is implemented. These projects are included in the environmental analyses to ensure consideration of potential cumulative effects. These other projects would be completed at different times throughout the study period. The potential cumulative environmental effects from these past, present and reasonably foreseeable projects are presented in **Chapter 5** of this DEIS. Mitigation is provided in **Chapter 6**.

## 4.1 Geological Elements

### 4.1.1 Topography and Soils

The evaluation of potential impacts to the physical setting and physiographic resources considered whether the proposed action or an alternative would cause any of the following conditions:

- Soil erosion or loss of topsoil
- The direct conversion of prime and unique farmland to non-agricultural uses
- Bank failure or subsidence

Impacts to the physical setting were assessed based on map and field resource data. The primary information about geology and soils was compiled using regional geology maps, the Liberty and Harris County Soil Survey Reports, and Natural Resources Conservation Service (NRCS) soil data as available. The environmental consequences discussed below addresses the potential impacts to the geology, mineral resources, and soil quality. Certain impacts to the physical setting are related to other resource concerns, specifically impacts from fugitive dust emissions and soil erosion; these effects are also discussed in the Climate and Air Quality, Social and Economic Resources (i.e., mineral resources) and Water Resources sections of **Chapter 4**.

The disturbance area describes the maximum area where potential impacts to the physical setting may occur including permanent impacts from structures such as the foundations for the proposed CRPS (approximately 90 acres in size) or the pump intake structure itself to be constructed along the west bank of the Trinity River including pump bays and stabilization headwall, the approximate 10 acre maintenance facility, linear access roads, siphon structures based on the final engineering design element to maintain local hydrology, and proposed sedimentation basin(s). The magnitude of potential effects from increased erosion or sedimentation and farmland acreage loss are defined by the disturbance area, while the presence or absence of materials not suitable for excavation or construction (e.g., unstable bank deposits or in areas with shifting currents or point bars) would determine the potential for erosion or sedimentation and potential for failure or need to implement an appropriate design for the angle and type of pump intakes to minimize effects to the opposite and adjoining/adjacent Trinity River shoreline/floodplain in the vicinity of property owned by the USFWS and part of the National refuge system.

### 4.1.2 Topography

Topographic effects include the potential land surface disturbance and alteration. The study area for direct and indirect impacts encompasses the proposed LBITP ROW, including the proposed preserved mitigation property. The topography cumulative effects study area is the same as the direct/indirect study area (see **Chapter 5**).

#### 4.1.2.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated ('build' alternative). As a result, no construction activities would occur and there would be no impact or change in baseline conditions related to topography with the exception of issues related to a potential increase in subsidence caused by the continued use of groundwater supply sources. In addition under No Action, topography within the proposed mitigation property would not be preserved. Lake Houston would continue to operate as the City's water supply and the NEWPP would not be expanded.

#### 4.1.2.2 Alternative 3A

The topography for Alternative 3A ranges from approximately 108 feet above MSL at the high point of Capers Ridge to approximately 40 feet above MSL at the Lake Houston discharge structure. The proposed ROW for the conveyance facilities totals approximately 1,005 acres and the CRPS totals approximately 90 acres. The total acreage estimated for Alternative 3A including the 10-acre maintenance facility is therefore approximately 1,105 acres.

Water in the proposed conveyance canal would flow by gravity from the topographic high point along Capers Ridge to Lake Houston, a difference in topography of approximately 70 feet. The topography of the study area has therefore positively and permanently benefited the project's design and allowed for the use of a low-cost, energy efficient, low-technology method (gravity flow) of transferring water from the Trinity River to Lake Houston. The topographic resources for Alternative 3A have positively and permanently benefited the project's design and allowed for the use of a low-cost, energy efficient, low-technology method of transferring water from the Trinity River to Lake Houston. The topographic resources available to Alternative 3A therefore eliminate or reduce potential impacts to energy use, energy conservation, and economics.

The location for the proposed Alternative 3A pipeline ROW and 300-foot wide easement was initially based on information provided by the *Alternatives Analysis Report* (2007) developed by the Applicant. Further refinement was provided for conveyance canal structure through the acquisition, processing and interpretation of LiDAR data. The project-specific LiDAR data were used to identify the topographic high areas representing the watershed divide in order to design/construction a conveyance structure that would minimize the change to area hydrology while not increasing the potential for flooding within the Cedar Bayou or Luce Bayou subwatersheds.

The topography of the study area, including the bathymetry of Lake Houston and along the Trinity River, was also studied based on project-specific water quality, sediment, flow data acquisition, modeling, and data analyses provided by individual reports, conclusions and recommendations.

Effects to and influences of topography and bathymetry have been and will continue to be incorporated into design considerations in order to minimize potential project effects to topography, hydrology, the potential to increase flood hazards, erosion, sedimentation, aesthetics, and bathymetry. Regional topography would not be permanently affected by Alternative 3A and local effects would be minimized to the extent possible using site-specific data collection and analyses incorporated into the final design for the proposed LBITP. During construction, land surface grading would occur, and permanent localized changes to topography or bathymetry may occur within the project footprint including at the discharge or intake locations, along the 300-foot wide ROW (approximately 1,005 acres), at the CRPS (approximately 90 acres), and at the proposed maintenance facility (approximately 10 acres). The LBITP ROW would be re-contoured after construction and it is expected that the surface expression would be a 26.5 miles long, linear, elevated or mounded/bermed, man-made surface feature.

The entire CRPS would be cleared and graded to facilitate the construction of the pump station and effects to the local topography would permanently occur. In general, Alternative 3A facilities would be similar in elevation to the surrounding landscape. In some areas, such as in the vicinity of existing bermed agricultural reservoirs (as applicable) or area roadways, the proposed open water canal would be elevated above the ground surface to maintain the existing land surface elevation.

#### 4.1.2.3 Alternative 4

The topography for Alternative 4 ranges from approximately 108 feet above MSL at the high point of Capers Ridge (near the proposed CRPS) to approximately 56 feet above MSL at the Lake Houston discharge structure. Water would be conveyed through dual, 108-inch (9-foot) diameter pipelines to Lake Houston. The area that would be affected by Alternative 4 construction totals approximately 895 acres (including the 10-acre maintenance facility). Topographic effects to the CRPS, a component of Alternative 4, are discussed in the section above (**Section 4.1.2.2**).

Alternative 3A and Alternative 4 share project features including the construction of CRPS, pipeline segment along Capers Ridge, and a proposed 300-foot ROW alignment extending across Liberty County close to FM 321.

In the project vicinity of Alternative 4, the topography and bathymetry along the Trinity River was studied based on project-specific water quality, sediment, flow data acquisition, modeling, and data analyses provided by individual reports, conclusions and recommendations. Effects to and influences of topography and bathymetry have been and would continue to be incorporated into design considerations in order to minimize potential project effects to topography, hydrology, the potential to increase flood hazards, erosion, sedimentation, aesthetics, and bathymetry. Regional topography is not expected to be permanently and adversely affected by Alternative 4, although local effects would be permanent and adverse. Although there would be efforts to minimize effects to local topography to the extent possible using site-specific data collection and analyses incorporated into the final design, it is expected that the 300-foot-wide surface expression of two buried 9-foot in diameter water pipelines within the proposed ROW would likely permanently result in adverse local topographic effects. During construction, land surface grading would occur along access roads and fences; however, the mounded, mowed, and maintained surface expression of the buried facilities (two, side-by-side 9-foot diameter pipes up to 15 feet deep) would permanently change local topography along the pipeline route extending for more than is 15 miles across the north-central portion of Liberty County. The LBITP ROW would be re-contoured after construction and it is expected that the surface expression would be 23.9 miles long, linear, elevated or mounded/bermed, man-made surface feature.

Local bathymetric changes would also occur within the area of potential effect for the project approximately 2,000 feet downstream of the CRPS. Permanent, localized, adverse effects of the LBITP would occur within the project footprint including at the discharge or intake locations, along the 300-foot-wide ROW (approximately 1,005 acres), at the CRPS (approximately 90 acres), and at the proposed maintenance facility (approximately 10 acres).

The entire CRPS would be cleared and graded to facilitate the construction of the pump station and effects to the local topography would permanently occur. The topography of the study area, including the bathymetry of Lake Houston and along the Trinity River, has been and will continue to be incorporated into design considerations in order to minimize potential project effects to topography and hydrology and that would increase the potential for flood hazards, erosion, sedimentation, aesthetics, and bathymetry. Regional topography would not permanently or adversely affected by Alternative 4. During construction, land surface grading would occur, and permanent localized changes to topography or bathymetry may occur within the project footprint including at the discharge or intake locations, and along the 300-foot-wide ROW (approximately 885 acres). In general, Alternative 4 facilities would not permanently affect regional topography, although permanent adverse topographic effects would occur in the area along the pipeline conveyance route.

#### 4.1.2.4 Alternative 6

The topography for Alternative 6 ranges from approximately 50 feet above MSL at the high point of Capers Ridge to approximately 43 feet above MSL at the Lake Houston discharge structure. Water would be pumped through two, 108-inch (9-foot) diameter pipelines between the existing TRPS and Lake Houston. The area that would be affected by Alternative 6 construction totals approximately 735 acres, including the 10-acre maintenance facility. No additional construction within the existing TRPS footprint itself would be expected during implementation of Alternative 6 although an evaluation of the need for additional sediment storage and management areas would be conducted during final design.

The location for the proposed pipeline ROW and 300-foot-wide easement was based on information provided by the Alternatives Analysis Report (2007) developed by the Applicant although the discharge locations to Lake Houston were updated for Alternatives 4 and 6. Effects to and influences of topography and bathymetry have been and would continue to be incorporated into design considerations in order to minimize potential project effects to topography, hydrology, the potential to increase flood hazards, erosion, sedimentation, aesthetics, and bathymetry. Regional topography is not expected to be permanently affected by Alternative 6, although local effects would be permanent and potentially significant. Although there would be efforts to minimize effects to local topography to the extent possible using site-specific data collection and analyses incorporated into the final design, it is expected that the 300-foot-wide surface expression of two, buried 9 foot in diameter water pipelines within the proposed ROW would likely permanently result in localized adverse topographic effects. During construction, land surface grading would occur along access roads and fences; however, the mounded, mowed, and maintained surface expression of the buried facilities (two, side-by-side 9-foot-diameter pipes up to 15 feet deep) would permanently change local topography along the pipeline route extending for more than 10miles across the south-central portion of Liberty County. The LBITP ROW would be re-contoured after construction and it is expected that the surface expression would be 21.4 miles long and would appear as a linear, elevated, mounded, bermed, manmade surface feature.

Local bathymetric changes would also occur within the area of potential effect for the project for an estimated minimum distance of 2,000 feet downstream of the existing TRPS (based on similar studies of possibly comparable pump station intake structures). Permanent, localized, adverse effects of the LBITP would occur within the project footprint including at the discharge or intake locations, along the 300-foot-wide ROW (approximately 725 acres) and at the proposed maintenance facility (approximately 10-acres).

#### 4.1.2.5 Mitigation

The greatest effect to topography for the regional study area has been evaluated for all three action alternatives identified for implementation as the LBITP. All three alternatives exhibit the potential to permanently affect, adversely change, or influence local topography and bathymetry of the lower Trinity River and Luce Bayou/Lake Houston. In the LBITP vicinity, the topography and bathymetry along the Trinity River would be studied using project-specific water quality, sediment, flow data acquisition, modeling, and data analyses, reports, conclusions and recommendations that would be incorporated into final design. Effects to and influences of topography and bathymetry have been and would continue to be incorporated into design considerations in order to minimize potential adverse project effects to topography, hydrology, the potential to increase flood hazards, erosion, sedimentation, aesthetics, and bathymetry.

LBITP includes the permanent construction of below-ground pipeline and, for Alternative 3A, open water above-grade canal structures, as well as construction of the CRPS or expansion/upgrade of the TRPS, and potential effects to topographic resources would occur related to land surface changes to topography and aquatic environment effects on bathymetry at the intake and discharge locations.

The location for the Alternative 3A conveyance canal structure was based on interpreting LiDAR data to identify the topographic high areas that would represent the watershed divide in order to design/construction a conveyance structure that would minimize the potential impacts to hydrology while not increasing the potential for flooding within the Cedar Bayou or Luce Bayou subwatersheds. The topography of the project area including Lake Houston and along the Trinity River have and will continue to be incorporated into design considerations in order to minimize potential project effects to topography, hydrology, the potential to increase flood hazards, erosion, sedimentation, aesthetics, and bathymetry. For example, intake and discharge structures would be angled with respect to the river or lake shoreline for all three action alternatives in order to minimize erosion and effects on sedimentation. During construction, permanent localized changes to topography or bathymetry may occur within the project footprint for all three action alternatives, including at the discharge or intake locations, and along the 300-foot-wide ROW.

For Alternatives 3A and 4, the CRPS would also be cleared, graded, and constructed and the design of the CRPS intake structure would be refined through hydrodynamic geomorphic modeling conducted during final design (see **Appendix I**). Flow deflection and potential adverse effects could be minimized or eliminated through improvements made to intake structure during the final design process. Such improvements include providing a gradual transition from the river bank to the edge of the intake structure and/or pulling the intake structure back into the river bank such that it does not extend as far into the river. Such improvements would minimize, or potentially eliminate the need for bank protection along the east bank of the Trinity River. In addition to the location of the intake and upstream approach, refined design to the intake apron would allow for optimization of the apron and reduce or eliminate the potential for toe scour and undermining of the intake foundation. Future modeling could be used to demonstrate the elimination of river scour on the east bank prior to construction.

Although the proposed pipeline alternatives (Alternatives 4 and 6) would be installed below-grade, the ROW would be mounded, graded, mowed, and maintained thus also permanently affecting local topography. In all cases, grading would occur to restore area topography to the extent possible after construction; however it is anticipated that permanent changes to topography would occur within the 300-foot ROW. The LBITP ROW would be re-contoured after construction and it is expected that the surface expression would range from 21.4 to 26.5 miles long, and would consist of a linear, elevated or mounded, fenced land surface feature. During final design, the exact number and placement of hydraulic flow conveyance structures (siphons and engineered drainage features) would be evaluated with the goal of minimizing the potential for localized topographic effects and to minimize the potential for water accumulation and flooding. Siphon structures and engineered drainage features would be installed to maintain hydrologic connection related to surface topography for the proposed pipeline sections of the LBITP to minimize the potential topographic and hydrologic effects of the constructed canal.

For Alternatives 4 and 6, effects to local topography and connectivity of drainage ditches and surface water bodies or other drainage or irrigation features would be maintained to minimize effects to topography and hydrologic resources. Sediment or soil erosion control measures in accordance with the National Pollutant Discharge Elimination System (NPDES) and Texas Pollutant Discharge Elimination System (TPDES) General Permit for Construction Activities would be implemented during the project's construction and operation to minimize discharging or moving stored sediment with storm water runoff into area water bodies, wetlands or the proposed canal. A Storm Water Pollution Prevention Plan (SWPPP) with Best Management Practices (BMPs) would be prepared as part of the LBITP discharge elimination permitting for construction activities. The SWPPP would contain spill prevention and response procedures meeting state and federal agencies requirements.

### 4.1.3 Soils

Soils effects include the potential disturbance and alteration of native soil profiles and soil structure, increased soil erosion and compaction, the loss of soil productivity, and change in infiltration rates and associated groundwater recharge. Based on sediment studies conducted, it is not anticipated that project soils would be contaminated with pollutants at concentrations requiring remedial action or regulatory notice.

The study area for direct and indirect impacts for soils encompasses the proposed LBITP ROW, including the proposed preserved mitigation property. The soils cumulative effects study area is the same as the direct/indirect study area in addition to surface disturbance associated with past and present actions within the prime farmland RSA (see **Chapter 5**).

#### 4.1.3.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, no construction activities would occur and there would be no impact or change in baseline conditions for soils. Top soils and surface/subsurface soils would not be disturbed and there would be no increase in the magnitude, intensity or duration of soil erosion or sedimentation that would occur, and no violation of federal, state or local floodplain laws, Executive Orders, rules, or ordinances related to soils or soil management would be expected. In addition under No Action, soils within the proposed mitigation property would not be preserved.

#### 4.1.3.2 Alternative 3A

The proposed ROW for the conveyance facilities totals approximately 1,005 acres, the CRPS totals approximately 90 acres, and the maintenance facility is approximately 10 acres in size. The total acreage estimated for Alternative 3A is therefore approximately 1,105 acres. Incremental surface disturbance to soil resources as a result of LBITP construction and operation would total up to 1,105 acres. Impacts also may occur during surface reclamation when vegetative growth materials are redistributed. Potential impacts to soils as a result of the Alternative 3A would include an increase in soil erosion due to the removal of vegetation, an alteration of soil structure, and a reduction in soil productivity. Although accelerated erosion due to soil disturbance could occur at any stage of the project, the maximum potential for erosion within the study area would be expected during construction and operation while soils are loose, with no established cover. The surface soils present within the Alternative 3A ROW are predominantly clays and clayey loams.

Soils and geologic features are influenced by the broad, flat coastal plain on which is deposited the clayey and sandy substrate of the Aluvium, Lissie, Beaumont, and Deweyville formations. During Alternative 3A construction, surface and subsurface soils at depths up to 15 feet below surface (pipeline segment) would be disturbed within the proposed ROW. The entire ROW would be cleared and graded and surface soils would be mixed during construction. Soils excavated within the Alternative 3A ROW would be used during construction and project preparation. To the maximum extent possible where required, material excavated from the canal and pipeline cuts would be used as fill material. If suitable soils are not found, they would be obtained from other sites within a reasonable haul distance from the project.

Soil compaction during construction would occur in areas that are heavily trafficked by vehicles and equipment. Soil compaction also could occur during closure of the excavation if equipment travels on, or handles, the soils when they are moist or wet. Native surface soils are loamy with moderate potential or susceptibility for water erosion. In areas with heavy clay soil textures (with related structural, crusting and compaction, and permeability limitations) there may exist a poor re-use suitability potential. In those areas, suitable overburden would be salvaged during operations as a replacement for excavated topsoil and subsoil of poor quality.

There may be selective handling plans for soils and overburden developed, designed to provide for segregation of sufficient oxidized material to provide a minimum 3-foot to 4-foot cover over pipeline segments. Soil suitability for reuse or reclamation would be determined by a testing program. Re-vegetation success would be determined in accordance with applicable procedures and standards and as described by permit conditions. Re-vegetation success would be monitored through evaluation of percent ground cover and productivity, as applicable, in relation to the site-specific post-project construction land uses.

Detailed investigation of soils for use during construction would be conducted during the project's final design phase. Localized long-term and permanent soil disturbance would occur, although soils on a regional basis would not be affected by the proposed project. Infiltration rates would increase due to the balanced particle size distribution and result in reduced storm water runoff and increased groundwater recharge. Mobile equipment (e.g., track hoes and end-dumps) would be used during construction of the LBITP and during sediment removal and management. Physical characteristics of the removed sediment from the Trinity River would be expected to represent fine sands or silts. The LBITP ROW would be re-contoured after construction and it is expected that the surface expression would be a 26.5 mile long, linear, elevated or mounded, man-made land surface feature.

#### 4.1.3.3 Alternative 4

The surface soils present within the Alternative 4 ROW are predominantly clays and clayey loams It is likely the entire ROW would be cleared and graded for the pipeline, CRPS, and maintenance facility (approximately 895 acres). The soils and geologic features are influenced by the broad, flat coastal plain on which is deposited the clayey and sandy substrate of the Aluvium, Lissie, Beaumont, and Deweyville formations. During Alternative 4 construction, surface soils at depths up to 15 feet below surface (pipeline segment) would be disturbed within the proposed ROW. Soils excavated within the Alternative 4 ROW would be used during construction and for burying the proposed pipelines. To the maximum extent possible where required, material excavated from the pipeline cuts would be used as fill or cover material. If suitable soils are not found, they would be obtained from other sites within a reasonable haul distance from the project. Detailed investigation of soils for construction would be conducted during the project's final design phase. Localized long-term and permanent soil disturbance would occur, although soils on a regional basis would not be affected by the proposed project.

#### 4.1.3.4 Alternative 6

The surface soil textures in Alternative 6 are predominantly clays and clayey loams. The soils and geologic features are influenced by the broad, flat coastal plain on which is deposited the clayey and sandy substrate of the Aluvium, Lissie, Beaumont, and Deweyville formations. During Alternative 6 construction, surface soils at depths up to 15 feet below surface (pipeline segment) would be disturbed and mixed within the proposed ROW. It is likely the entire ROW and 735 acres, including the area of the maintenance facility, would be cleared and graded. Soils excavated within the Alternative 6 ROW would be used during construction and project preparation. To the maximum extent possible where required, material excavated from the canal and pipeline cuts would be used as fill material. If suitable soils are not found, they would be obtained from other sites within a reasonable haul distance from the project. Detailed investigation of soils for construction would be conducted during the project's final design phase. Localized long-term and permanent soil disturbance would occur, although soils on a regional basis would not be affected by the proposed project.

#### 4.1.3.5 Mitigation

The proposed LBITP alternatives could include the permanent construction of both below-ground pipeline and open water above-grade canal structures, as well as construction of the CRPS, potential effects to soils related to implementation of the LBITP focuses on surface soils and potential for erosion.

For all alternatives, surface grading, excavation filling and soil removal and/or mixing would occur during construction of the LBITP. During operation, eroded soils generated from the sediments present in the water to be removed from the Trinity River would be generated, need to be removed via the sedimentation basin and managed appropriately (stockpiled for future use or disposed of/managed appropriately). Reclamation and the installation of erosion control measures and devices would minimize erosion and the potential for sediment to leave the construction site. Sediment or soil erosion control measures in accordance with the NPDES and TPDES General Permit for Construction Activities would be implemented during the project's construction and operation to minimize discharging or moving stored sediment with storm water runoff into area water bodies, wetlands or the proposed canal. A SWPPP with BMPs would be prepared as part of the LBITP discharge elimination permitting for construction activities. The SWPPP would contain spill prevention and response procedures meeting state and federal agencies requirements. Based on the planned implementation of erosion control measures during construction (e.g., sediment control ponds, diversion ditches, silt fences, straw bales, and re-vegetation measures), the potential for localized soil erosion as a result of the discharge of surface water from the construction site is anticipated to be low to moderate and temporary.

### 4.1.4 Prime Farmland Soils

Prime farmland soils effects include the potential disturbance and alteration of native soil profiles and soil structure, increased soil erosion and compaction, the loss of soil productivity, and change in infiltration rates and associated groundwater recharge.

The study area for direct and indirect impacts for prime farmland soils encompasses the proposed LBITP ROW, including the proposed preserved mitigation property. The prime farmland soils cumulative effects study area is the same as the direct/indirect study area in addition to surface disturbance associated with past and present actions within the prime farmland RSA (see **Chapter 5**).

#### 4.1.4.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, no construction activities would occur and there would be no impact or change in baseline conditions related to prime farmland soils. Prime farmland soils would not be disturbed and there would be no increase in the magnitude, intensity or duration of prime farmland soil erosion or sedimentation that would occur, and no violation of federal, state or local floodplain laws, Executive Orders, rules, or ordinances related to prime farmland soils would be expected. In addition under No Action, prime farmland soils within the proposed mitigation property would not be preserved.

#### 4.1.4.2 Alternative 3A

Prime farmland soils are prevalent throughout the study area and within the footprint and ROW needed for the construction and operation of Alternative 3A. The proposed ROW for the conveyance facilities totals approximately 1,005 acres, the CRPS totals approximately 90 acres, and the maintenance facility totals approximately 10 acres in size. The total acreage needed for Alternative 3A is therefore approximately 1,105 acres. Alternative 3A traverses agricultural areas that contain prime farmland soils. The area is used for agriculture, ranching, and timber production.

Prime farmland soil impacts were analyzed for the project's construction, operation and maintenance. Constructing Alternative 3A would permanently convert existing farmland or prime farmland soils to municipal water supply land use. Attempts to avoid prime farmland soils were made during project planning. However, due to the large acreage of this resource in Harris and Liberty Counties, the project would have an unavoidable, permanent direct effect on prime farmland soils and prime farmland soils, if irrigated, within the Alternative 3A ROW and would affect approximately 746 acres. **Table 4-1** presents the direct impacts to prime farmland soils for Alternative 3A ROW.

**Table 4-1:**
**Prime Farmland Soils within the Alternative 3A ROW**

| MUSYM | Name | Acres |
|---|---|---|
| AdA | Aldine silt loam, 0 to 2 percent slopes | 40.70 |
| Ae | Aldine-Aris complex | 97.89 |
| An | Anahuac-Aris complex | 18.11 |
| Ba | Beaumont clay | 236.01 |
| Bd | BERNARD CLAY LOAM | 14.94 |
| Be | Bernard clay loam | 2.51 |
| Bm | Bernard-Morey complex | 189.06 |
| Ka | Kaman clay, occasionally flooded | 1.42 |
| LaA | League clay, 0 to 1 percent slopes | 16.74 |
| LcA | LAKE CHARLES CLAY, 0 TO 1 PERCENT SLOPES | 62.66 |
| Md | MIDLAND SILTY CLAY LOAM (VERLAND) | 15.62 |
| My | Mocarey-Yeaton complex | 12.00 |
| Oz | Owentown fine sandy loam, occasionally flooded | 1.25 |
| SrB | Spurger fine sandy loam, 0 to 2 percent slopes | 8.88 |
| VaA | Vamont silty clay, 0 to 1 percent slopes | 10.76 |
| VaB | Vamont clay, 1 to 3 percent slopes | 3.75 |
| Wa | Waller loam | 13.51 |
| | **TOTAL** | **745.80** |

### 4.1.4.3 Alternative 4

Prime farmland soils are prevalent throughout the study area and within the footprint and ROW needed for the construction and operation of Alternative 4. The proposed ROW for the conveyance facilities totals approximately 885 acres, the CRPS totals approximately 90 acres, and the maintenance facility approximately 10 acres. The total acreage needed for Alternative 4 is therefore approximately 985 acres. Alternative 4 traverses agricultural areas that contain prime farmland and is used for agriculture, ranching, and timber production.

Prime farmland soil impacts were analyzed for the project's construction, operation and maintenance. Construction of Alternative 4 would permanently convert existing farmland or prime farmland soils to municipal water supply land use. Attempts to avoid prime farmland soils were made during project planning. However, due to the large acreage of this resource in Harris and Liberty Counties, the project would have an unavoidable, permanent direct effect on prime farmland soils within the Alternative 4 ROW and would affect approximately 686 acres. **Table 4-2** presents the direct impacts to prime farmland soils for Alternative 3A ROW.

**Table 4-2:**
**Prime Farmland Soils within the Alternative 4 ROW**

| MUSYM | Name | Acres |
|---|---|---|
| AdA | Aldine silt loam, 0 to 2 percent slopes | 8.01 |
| Ae | Aldine-Aris complex | 118.08 |
| An | Anahuac-Aris complex | 2.39 |
| Ba | Beaumont clay | 17.55 |

| | | |
|---|---|---|
| Bm | Bernard-Morey complex | 132.06 |
| Ka | Kaman clay, occasionally flooded | 0.27 |
| LaA | League clay, 0 to 1 percent slopes | 46.72 |
| LcA | Lake Charles Clay, 0 to 1 percent slopes | 107.37 |
| Md | MIDLAND SILTY CLAY LOAM (VERLAND) | 48.51 |
| My | Mocarey-Yeaton complex | 191.04 |
| SrB | Spurger fine sandy loam, 0 to 2 percent slopes | 3.81 |
| VaA | Vamont silty clay, 0 to 1 percent slopes | 2.27 |
| Wa | Waller loam | 7.55 |
| | **TOTAL** | **685.62** |

#### 4.1.4.4 Alternative 6

Prime farmland soils are prevalent throughout the study area and within the footprint and ROW needed for the construction and operation of Alternative 6. The proposed ROW for the conveyance facilities totals approximately 725 acres and the maintenance facility totals 10 acres. The total acreage needed for Alternative 6 is therefore approximately 735 acres because the existing TRPS is already constructed thereby representing baseline conditions. Alternative 6 traverses agricultural areas that contain prime farmland and is used for agriculture, ranching, and timber production.

Prime farmland soil impacts were analyzed for the project's construction, operation and maintenance. Constructing Alternative 6 would permanently convert existing farmland or prime farmland soils to municipal water supply land use. Attempts to avoid prime farmland soils were made during project planning. However, due to the large acreage of this resource in Harris and Liberty Counties, the project would have an unavoidable, permanent direct effect on prime farmland soils within the Alternative 6 ROW and would affect approximately 618 acres. **Table 4-3** presents the direct impacts to prime farmland soils for Alternative 6 ROW.

**Table 4-3:**
**Prime Farmland Soils within the Alternative 6 ROW**

| MUSYM | Name | Acres |
|---|---|---|
| Ae | Aldine-Aris complex | 9.79 |
| Ba | Beaumont clay | 94.74 |
| Bd | BERNARD CLAY LOAM | 60.89 |
| Be | Bernard clay loam | 125.32 |
| Bm | Bernard-Morey complex | 109.68 |
| LaA | League clay, 0 to 1 percent slopes | 50.86 |
| LcA | LAKE CHARLES CLAY, 0 TO 1 PERCENT SLOPES | 91.21 |
| Md | MIDLAND SILTY CLAY LOAM (VERLAND) | 24.43 |
| My | Mocarey-Yeaton complex | 13.26 |
| Oa | OZAN LOAM | 25.86 |
| VaA | VAMONT CLAY, 0 TO 1 PERCENT SLOPES | 12.29 |
| | **TOTAL** | **618.32** |

#### 4.1.4.5 Reduction and Mitigation of Potential Impacts

The greatest effect to prime farmland soils within the regional study area has been evaluated for all three action alternatives; based on this analysis, the greatest change to prime farmland soils and agricultural areas would be expected to occur for Alternative 3A. Since this alternative includes the permanent construction of both below-ground pipeline and an open water, above-grade canal structures, as well as construction of the CRPS, potential effects to prime farmland soils related to implementation of Alternative 3A would exceed those that would occur for Alternatives 4 and 6. This discussion regarding the reduction and mitigation of potential impacts focuses on the potential effects related to the construction and operation of Alternative 3A in order to provide the proper framework for understanding the range of possible mitigation strategies that may be effective or considered for implementation.

In accordance with Farmland Protection Policy Act (7 USC Part 658), and considering Part 658.5, farmland assessment criteria were developed by the Secretary of Agriculture in cooperation with other Federal agencies. Farmland assessment criteria are considered and evaluated using a scoring system provided by Natural Resource Conservation Service (NRCS) Form CPA-106. Farmland assessment criteria are considered in two parts (1) the land evaluation criterion/relative value and (2) the site assessment criteria.

The land evaluation criterion addresses permanent and direct farmland soil loss and is based on information from several sources including soil surveys; NRCS field office technical guides, soil potential ratings or productivity ratings, land capability classifications, and important farmland determinations. Based on this information, groups of soils within a local government's jurisdiction will be evaluated and assigned a score from 0 to 100, representing the relative value, for agricultural production, of the farmland to be converted by the project, as compared to other farmland in the same local government jurisdiction.

The site assessment criterion include a number of considerations which are designed to supplement the information gained about farmland soil loss during the land evaluation and relative value part of the farmland assessment. The site assessment criteria make it possible to assess the project in a broader context by taking into consideration numerous factors such as the history of agriculture in the area and the potential impact to agriculture based economics and infrastructure.

These criteria help to assess what the project means to the agricultural future of the area, and the project’s role in promoting non-agricultural use; the potential for interference with land patterns which would result in remaining land becoming fragmented and non-farmable. They identify:

- State and local government policies as well as private programs that protect area farmland
- The size of area farms relative to average-sized farms in the county
- The presence of farm support services and markets, (i.e., farm suppliers, equipment dealers, processing and storage facilities and farmer's markets)
- The presence of substantial on-farm investments, such as barns, storage buildings, fruit trees and vines, field terraces, drainage, irrigation, waterways, and soil and water conservation measures
- The potential for the project to reduce the demands for these farm services, jeopardize their existence, and impact viability of other farms in the area

Farmland scoring on NRCS Form CPA-106 is based upon a possible 260 points. Projects receiving scores totaling less than 160 points are given a minimal level of consideration for protection, and typically require no coordination with the NRCS. For each criterion a score is given on a scale of 0 to a maximum number of points. Scoring decisions are made through research and examination of the site and the surrounding area. Where one given location has more than one design alternative, each design is considered as an alternative site. For this project, the Alternative 3A was subjected to the farmland scoring criteria on NRCS Form CPA-106 as was Alternative 1—No Action Alternative, so a comparison could be made on their relative impact to farmland in the study area.

Using NRCS Form CPA-106, both Alternative 3A and the No Action Alternative scored 55 out of a possible 260 total points. A score of 55 that is well below the 160 point recommended allowable level for determining when adverse impacts may occur as a result of project-related construction, operation, and maintenance activities. The construction, operation, and maintenance of Alternative 3A would permanently and directly impact more than 140 acres of active and formerly active agricultural lands; however, the project is not anticipated to adversely impact overall agricultural services and operations in the study area. The low scoring site assessment outcome is the result of efforts made during the project planning process to follow existing property boundaries as possible. With the exception of the alignment of Alternative 3A along the property owned by the Stoesser Family, Inc. (Parcels 22 to 33), the proposed alignment for Alternative 3A was developed along existing property boundaries where possible to minimize the isolating or fragmentation of communities, operating farms or agricultural or commercial properties. The Alternative 3A alignment through prime farmlands and prime farmland soils resources present at property owned by Stoesser Farms, Inc. was refined to provide the following benefits:

- Avoidance of the agricultural reservoir in the northern portions of Parcels 28 through 32, thereby eliminating unavoidable impacts to this reservoir that would have reduced the volume, decreased the capacity, permanently removed ancillary irrigation and drainage equipment from that location, and would've caused the reconstruction and restoration of the northern reservoir berm and the existing water bird rookery.

- Elimination of the need to remove and permanently relocate a large-scale farming irrigation pump and ancillary irrigation facilities and the farming irrigation canal that extends from the reservoir.

- Minimization of direct, permanent impacts to drainage ditches that convey irrigation water and storm water runoff away from the adjoining farm fields.

- Comply more closely with identified subwatershed drainage boundaries (based on flow line directional maps) in order to construct the proposed canal along the hydrologic drainage divide in order to avoid, reduce and minimize the effects on the local hydrology in the vicinity of the farm and to reduce, potentially eliminating, the potential for an increase of localized flooding or surface water runoff, water ponding, water flushing, or a direct effect to the water retention/functioning of the contoured terraces of the adjoining fields.

- Avoidance of the replacement of landowner's infrastructure associated with Stoesser Farms, Inc. operations and facilities (e.g., roads, gates, ditches, fences, signage, GPS stations, culverts, gates, crossings, etc.).

### 4.1.5 Geology and Groundwater

Environmental effects of the LBITP associated with geology and groundwater resources include topographic changes to the project area, the potential for disruption from geologic hazards, and the effects of mining or over-pumping of groundwater resources in the study area. The study area for direct and indirect impacts to geology and groundwater encompasses the area within the Region H RWP boundary, proposed LBITP ROW, proposed and existing pump stations and IBT discharge locations, and the area of the mitigation property. The geology and groundwater cumulative effects study area encompasses the area of direct effects (**Chapter 5**).

#### 4.1.5.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, no construction activities would occur and there would be no impact or change in baseline conditions related to geology and groundwater with one exception. There would be an increase in the magnitude, intensity or duration of groundwater withdrawal rates under No Action as Houston uses groundwater to meet contracted water demands and needs of the Region H populations rather than surface water sources. The subsidence district requirements to reduce pumping of groundwater within Harris, Galveston, Montgomery, and Fort Bend Counties, Texas would not be met which would result in violations and resulting user fees that would be needed using public monies (varies by subsidence district plan. In addition under No Action, geology and groundwater sources (springs, bayous, streams, seeps) would not be preserved at the proposed mitigation property.

#### 4.1.5.2 Alternative 3A

The surface geology within the Alternative 3A ROW consists predominantly of Quaternary Age relict alluvial, deltaic and coastal deposits which have been uplifted to form topographic river terraces and modem alluvial deposits occurring along the Trinity River, Cedar Bayou, Gillen Bayou, and Luce Bayou. Shallow sediments include clays and silty clays interbedded with discontinuous layers of silts and sands. The project's construction, operation and maintenance would not be expected to have a direct or permanent effect on regional geology.

The Gulf Coast aquifer was deposited in a manner that resulted in interbedded sand and clay layers with a substantial thickness of sand that contains good quality water. Large fresh water quantities extend to 1,800 feet below sea level, and this aquifer has been used over the past 100 years. Pumping large water quantities from this aquifer has caused the potentiometric head of the aquifer to decline from between 50 and 350 feet in Region H RWP boundary. By implementing the proposed project, regional groundwater resources would directly and indirectly permanently benefit through conversion to surface water supply sources. Alternative 3A's construction, operation, and maintenance would not be expected to affect groundwater availability in the project area. Subsidence is discussed in **Section 4.1.6.**

#### 4.1.5.3 Alternative 4

The surface geology within the Alternative 4 ROW consists predominantly of Quaternary Age relict alluvial, deltaic and coastal deposits which have been uplifted to form topographic river terraces and modem alluvial deposits occurring along the Trinity River, Cedar Bayou, Gillen Bayou, and Luce Bayou. Shallow sediments include clays and silty clays interbedded with discontinuous layers of silts and sands. The project's construction, operation and maintenance would not be expected to have a direct or permanent effect on regional geology.

The Gulf Coast aquifer was deposited in a manner that resulted in interbedded sand and clay layers with a substantial thickness of sand that contains good quality water. Large fresh water quantities extend to 1,800 feet below sea level, and this aquifer has been used over the past 100 years. Pumping large water quantities from this aquifer has caused the potentiometric head of the aquifer to decline from between 50 and 350 feet in Region H RWP boundary. By implementing the proposed project, regional groundwater resources would directly and indirectly permanently benefit through conversion to surface water supply sources. Alternative 4's construction, operation, and maintenance would not be expected to affect groundwater availability in the project area. Subsidence is discussed in **Section 4.1.6.**

#### 4.1.5.4 Alternative 6

The surface geology within the Alternative 5 ROW consists predominantly of Quaternary Age relict alluvial, deltaic and coastal deposits which have been uplifted to form topographic river terraces and modem alluvial deposits occurring along the lower Trinity River, Cedar Bayou, and Goose Creek. Shallow sediments include clays and silty clays interbedded with discontinuous layers of silts and sands. The project's construction, operation and maintenance would not be expected to have a direct or permanent effect on regional geology.

The Gulf Coast aquifer was deposited in a manner that resulted in interbedded sand and clay layers with a substantial thickness of sand that contains good quality water. Large fresh water quantities extend to 1,800 feet below sea level, and this aquifer has been used over the past 100 years. Pumping large water quantities from this aquifer has caused the potentiometric head of the aquifer to decline from between 50 and 350 feet in Region H RWP boundary. By implementing the proposed project, regional groundwater resources would directly and indirectly permanently benefit through conversion to surface water supply sources. Alternative 6's construction, operation, and maintenance would not be expected to affect groundwater availability in the project area. Subsidence is discussed in **Chapter 2** and below in **Section 4.1.6**.

#### 4.1.5.5 Reduction and Mitigation of Potential Impacts

LBITP is the Interbasin transfer of surface water to provide needed water to the metropolitan Houston area. The greatest effect to geology and groundwater resources would occur if the No Action Alternative would be implemented. Possible mitigation strategies that may be effective or considered for implementation to reduce and mitigation potential impacts of No Action would be the responsibility of others and are therefore not identified for implementation by the Applicant.

### 4.1.6 Subsidence

Environmental effects of the LBITP associated with subsidence would include the area that would experience changes (decrease) in land surface elevation as a result of increased groundwater withdrawals within the project area. Sea level rise (climate change) combined with subsidence would tend to increase the land area that would experience the land elevation decrease (i.e., subsidence) caused by an increase in the groundwater withdrawal rate and subsequent compaction or collapse of the aquifer's interstitial pore space/granular structure as stored water is removed from the aquifer and not replenished at a sufficient recharge rate to meet water pumping rates caused by public water demands. Under No Action, there is strong scientific evidence that subsidence would occur and the rate of subsidence would increase since there would be an increased demand for the use of groundwater withdrawals for water supply under No Action.

Subsidence increases the frequency and intensity of flooding and increases the amount of land subject to tidal inundation. Hurricane evacuation routes are made vulnerable by being flooded far in advance of approaching storms. Another widespread consequence of subsidence is the alteration of natural and engineered drainage ways by reducing or increasing pre-existing gradients. Reduced gradients decrease the drainage rate and thereby increase the chance of flooding by storm water runoff. Enhanced gradients may increase runoff velocities locally, but may increase flooding chances downstream. Changed gradients can also alter stream flow characteristics leading to channel erosion and sediment deposition. **Figure 1-1** shows Area 3's Historical and Predicted Subsidence from 1906 to 2030 (HGSD 2011).

Wetland losses due to subsidence are varied and cause significant effects to area stream and bay fisheries. It is estimated 26,000 acres of emergent wetlands in the Galveston Bay system have been lost due to subsidence impacts on shorelines (USGS Galloway et al. 1999). Once destabilized, shorelines may not rebuild completely due to a variety of other causes including sediment loss due to reservoir construction on the riverine systems flowing into Galveston Bay, and relative sea level rise exacerbated by subsidence, which drowns shoreline marsh vegetation. The combination of these man-induced changes and natural processes results in reduced wetland habitat, which is the foundation for commercial and recreational fisheries (USGS Galloway et al. 1999).

The extent of subsidence continues to be monitored using increasingly precise technology such as radar interferometry (Buckley et. al. 2003). One of the many efforts to quantify subsidence extent was accomplished by USGS scientists who provided the following description:

> *By 1943 subsidence had begun to affect a large part of the Houston area although the amounts were generally less than 1 foot. By the mid-1970s, six or more feet of subsidence had occurred throughout an area along the Ship Channel between Bayport and Houston, as a result of declining groundwater levels associated with rapid industrial expansion. During this time, subsidence problems took on crisis proportions, prompting the creation of the Harris-Galveston Subsidence District. By 1979 up to 10 feet of subsidence had occurred and almost 3,200 square miles had subsided more than 1 foot.* (USGS Galloway et. al. 1999).

Earlier estimates indicate between 1947 and 1973, approximately 4,700 square miles of land surface had subsided by at least 0.5 feet, primarily in Houston-Galveston area's southeastern portions (Brown and Root Engineers 1979).

Subsidence's cost has been evaluated in various ways. One estimate placed the annual cost of reclaiming land, elevating structures including roadways and relocating other infrastructure, and constructing levees for the period 1969 to 1974 at over $90 million annually in 1998 dollars. Restoring dock and wharf facilities along the Houston Ship channel, and repairing damages to refineries has been estimated at over $340 million (1998 dollars). Other estimates for infrastructure damage and structural damage to residences and businesses across subsidence-affected areas are in the billions of dollars. The cost for wetland losses and resulting impacts to fisheries has not been estimated (USGS Galloway et al.1999).

Implementing the 1976 Subsidence District plan caused Galveston Bay industries to convert from using groundwater to using surface water from Lake Livingston in the Trinity River basin. Baytown and Pasadena land areas began to recover from some problems caused by subsidence as a result of the conversion. Surface water supplied from Lake Houston in the San Jacinto River basin plus additional water from Lake Livingston led to slowed and halted water level declines and to water level recovery over a large area. The Houston's eastern areas have seen less subsidence since the conversion, but areas in the western part of Houston (Area 3 on **Figure 1-2**) have experienced accelerated subsidence because groundwater use is not as restrictive. The Fort Bend Subsidence District (created in 1989) has also developed a regulatory action plan which would reduce that county's groundwater pumpage by 80 percent by 2020.

**Figure 1-2** shows Areas 1, 2 and 3 Conversion Requirements in the 2009 Surface Water Conversion Plan. Generally, Houston's metropolitan areas and surrounding communities and industrial land uses are being regulated in their groundwater use with the view to transition to surface water supplies. Various areas have different transition or conversion objectives, but stopping subsidence by eliminating or significantly reducing groundwater use is the principal goal. Regulating groundwater use in the Houston region is a scheduled process, with each numbered regulated area of the region carefully monitored in its ground and surface water use as shown in **Figure 1-3** (HGSD 2011).

As of 2010, the conversion to surface water in Regulatory Area 1, which includes Galveston, Brazoria, and coastal areas of Harris Counties, was almost complete. Regulatory Area 1 pumped at least 140 MGD in 1976; by 2010 this amount had decreased to less than 9 MGD. Area 2, which encompasses southeast, south central and parts of west and southwest Harris County, had pumped almost 40 MGD in 2010, which is a significant reduction from previous decades. During the 1970s through the early 1990s, this area was withdrawing more than 120 MGD on the average, and major reductions were not realized until the early 2000s. Regulatory Area 3 pumped more than 195 MGD in 2010, which reflects this area's lack of surface water availability. The water contracts between Houston and the various water authorities with jurisdiction in Area 3 would allow this area to significantly reduce groundwater use and thereby reduce the ongoing effects of subsidence.

Supplementing Lake Houston with previously permitted water in Lake Livingston would help Houston meet the contracted volumes for Regulatory Areas 2 and 3. At the same time, the additional water supply appears to affect Area 3's groundwater use in 2020, when this water will be available to the water authorities. In 2010, the public water supply demand in Area 3, sourced by groundwater, was calculated to be 178 MGD (HGSD 2011). Each of the Area 3 water authorities has contracted with Houston to provide 221 MGD of treated water by 2020. This will require the supplemental supply from the Trinity River and Lake Livingston. If Area 3 maintains or only slightly decreases groundwater pumpage between 2011 and 2020, the new infusion of surface water would effectively eliminate the need to use groundwater for public supply. This calculation does not consider other groundwater uses such as industry or agriculture. Based on studies conducted, the proposed LBITP would contribute substantially to a decrease in groundwater use in the Regulatory Area 3 (Houston 2011; HGSD 2011).

#### 4.1.6.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, no construction activities would occur. Baseline conditions related to subsidence in the LBITP ROW area would likely not change with respect to subsidence for the foreseeable future. However, Houston would likely continue to use groundwater sources for water supply sources and subsidence management plans would not be met. Subsidence would therefore continue to occur in the Houston metropolitan area and there would be an increase in the magnitude, intensity or duration of subsidence that would occur, and local subsidence district plans for management of subsidence would not be implemented in a timely manner. This would result in a potential violation of local requirements for change to surface water supplies from groundwater resources. Due to continuation of subsidence, flooding may be exacerbated in the Region H RWP area, and localized subsidence and flooding in central, western and northern Harris County would continue, gradually increasing in intensity, duration, severity and recovery time as water supplies are increased to meet forecasted population demand.

#### 4.1.6.2 Alternative 3A, Alternative 4 and Alternative 6

Land surface subsidence (sinking) in the Region H planning area and in the vicinity of the proposed build alternatives does occur when very large groundwater quantities are pumped from the Chicot or Evangeline Aquifers for water supply. The amount of subsidence that has occurred in proximity to the proposed LBITP alternatives in Liberty County and eastern Harris County, Texas is approximately 1 foot. The major subsidence area occurs in outside of the area of potential effect for the action alternatives, in western, central Harris County, southern Montgomery, and northern Galveston Counties where large groundwater quantities have been pumped for decades for water supply.

One purpose for the LBITP is to meet the HGSD-mandated groundwater reduction plan to limit groundwater use by Houston area municipalities to 20 percent of total demand by 2030. Significant land subsidence has occurred in the region from excessive pumping from area groundwater aquifers. The HGSD and the Fort Bend County Subsidence District have developed regulatory plans which mandate reducing groundwater pumping starting in 2010 and 2013, respectively, and continuing through 2030. LBITP is a cornerstone of the plans to reduce subsidence in the Houston area. Increased and interim groundwater pumping in the region will continue to be monitored by groundwater regulatory agencies, since excessive pumping can lead to land subsidence and exacerbate flooding and drainage problems. Regional subsidence would be controlled and the area permanently benefitted by the planned conversion from groundwater to surface water sources as part of LBITP's planned construction, operation, and maintenance. A direct, positive permanent regional beneficial effect to control area subsidence is anticipated as a result of LBITP's construction, operation, and maintenance.

The Gulf Coast aquifer was deposited in a manner that resulted in interbedded sand and clay layers with a substantial thickness of sand that contains good quality water. Large fresh water quantities extend to 1,800 feet below sea level, and this aquifer has been used over the past 100 years.

Pumping large water quantities from this aquifer has caused the potentiometric head of the aquifer to decline from between 50 and 350 feet in Region H. By implementing LBITP, regional groundwater resources would directly and indirectly benefit through conversion to surface water supply sources. LBITP's construction, operation, and maintenance would not be expected to affect groundwater resources in the project area with the effect that subsidence would continue to be managed in accordance with local district plans.

#### 4.1.6.3 Mitigation

LBITP is the Interbasin transfer of surface water to provide needed water to the metropolitan Houston area. Under the No Action Alternative, the proposed LBITP would not be constructed or operated. The greatest effect to subsidence would occur if the No Action Alternative would be implemented. A possible reduction in subsidence or mitigation strategies to reduce subsidence that may be effective or considered for implementation would be the responsibility of others and are therefore not identified for implementation by the Applicant. In addition, as subsidence would continue, the land surface elevation would decrease and flooding may be exacerbated in the Region H RWP area. The responsibility to manage or control effects of subsidence, including flooding, would be the responsibility of others under the No Action Alternative.

### 4.1.7 Sedimentation and Erosion

Geomorphology is the geologic study of landforms and processes that affect landforms including sedimentation and erosion. Changes in stream flow may affect erosion, sedimentation and other processes that affect stream channel characteristics and stability. Hydrographic modeling would be incorporated into final design activities to minimize and control these potential effects. Geomorphology is a relevant topic associated with the effects from the proposed project due to potential changes in channel stability which could occur with changes in stream flow. Reductions in channel stability could result in eroding stream channels or banks, which could cause banks to collapse or change stream meander patterns. Land owners and water users downstream from these changes could be affected (e.g., sedimentation could lead to reduced water quality or diversion capacity in diversion structures, and erosion could cause property loss). Geomorphic indicators used in this analysis are:

- Sediment transport capacity at proposed withdrawal rates
- Grain size distribution for sediments removed from the Trinity River
- Potential changes to stream flow

The study area for direct and indirect effects to sedimentation and erosion encompasses the proposed LBITP ROW, the lower Trinity River in the vicinity of the proposed CRPS and existing TRPS diversion locations, the proposed three LBITP discharge locations that outfall to Lake Houston, and the area of the mitigation property. The sedimentation and erosion cumulative effects study area encompasses the area of prime farmland RSA (**Chapter 5**).

Environmental effects of the LBITP associated with sedimentation and erosion includes the area of the proposed alternatives within the 300-foot ROW, the lower Trinity River for a distance of approximately 2,000 feet downstream of the CRPS and the TRPS diversion points, within approximately 1,000 feet of the Lake Houston discharge locations, and the following watersheds: lower Trinity River, Cedar Bayou, North Galveston Bay, and Galveston-San Jacinto River watersheds.

#### 4.1.7.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, no construction activities would occur and there would be no impact or change in baseline conditions related to sedimentation and erosion. Sedimentation and erosion would not be altered or affected and there would be no increase in the magnitude, intensity or duration of sedimentation or erosional effects that would occur, and no violation of federal, state or local floodplain laws, Executive Orders, rules, or ordinances would be expected. Lake Houston would continue to operate as the City’s water supply reservoir and would provide sufficient water until 2020.

#### 4.1.7.2 Alternative 3A

The area of direct influence for Alternative 3A for sedimentation and erosion includes the proposed location of Alternative 3A facilities including roads, pipeline, canal, pump and discharge stations, the sedimentation basin, maintenance facility and utility lines, and the lower Trinity River from the permitted Capers Ridge diversion point to approximately 2,000 feet downstream from this proposed pump station intake structure. The final pump station design would include engineering considerations and conducting a modeling effort to minimize the direct long-term effect on the Trinity River and Luce Bayou banks and sediments in the proposed diversion and discharge structures' vicinity (see AECOM Technical Memorandum dated March 20, 2012 in the **Appendix I**).

The location for the Alternative 3A conveyance canal structure was based on interpreting LiDAR data to identify the topographic high areas that would represent the watershed divide in order to design/construction a conveyance structure that would minimize the potential impacts to hydrology while not increasing the potential for flooding within the Cedar Bayou or Luce Bayou subwatersheds. Consideration of soils, topography, bathymetry and surface water within the project area, including Lake Houston and along the Trinity River, has been and will continue to be incorporated into the final design to minimize potential effects to topography, hydrology, the potential to increase flood hazards, erosion, sedimentation, aesthetics, and bathymetry. For example, intake and discharge structures would be angled and placed at an optimum depth with respect to the water surface to minimize sedimentation and erosion. Design considerations would also include water surface elevations, fluctuations of the water surface, the location, depth, type, stability, and thickness of the banks of the surface water bodies (river, bayou, or lake) for all three action alternatives in order to minimize erosion and effects to sedimentation, the ecological environment, and flow regime. All three alternatives transfer water from the lower Trinity River to Lake Houston, the San Jacinto River watershed. The seven major tributaries that flow into Lake Houston include Cypress Creek, Spring Creek, West Fork of San Jacinto River (West Fork), Caney Creek, Peach Creek, East Fork of San Jacinto River (East Fork) and Luce Bayou.

During construction, permanent localized changes to bathymetry may occur at the discharge or intake locations and to sediments in the area of potential effect upstream and downstream of the structures installed within a surface water feature. For Alternatives 3A and 4, the CRPS would also be cleared, graded, and constructed and the design of the CRPS intake structure would be refined through hydrogeomorphic modeling to minimize the effects to sedimentation and erosion within the lower Trinity River that would be conducted during final design. Baird conducted studies to evaluate the effects of the proposed water withdrawal at the CRPS (Baird 2010; **Appendix I**) and the results are presented below.

Baird used an approach based on the annualized sediment budget analysis scenario developed by the USACE, sediment budget data were annualized to represent typical flow conditions by integrating the flow regime over the observed discharge frequencies identified after construction of Lake Livingston and recorded at the USGS Romayor stream gauge (see **Figures 4-2** and **4-3**). Flow values listed along the x-axis of these figures were chosen to represent the full range of flows over which water withdrawal would occur (up to, and including, the 10 year event). In this analysis, only flow records from after the Lake Livingston Dam was built were used for frequency analysis to best represent current and future conditions. Flow releases from Lake Livingston were assumed in the frequency analysis to maintain minimum flows of 700 cfs downstream of the intake. The 700 cfs minimum flow value was established to estimate the impact that a minimum flow requirement would have on the sediment transport near the proposed project site. For example, for a 400 MGD scenario, which equates to approximately 620 cfs, the flow upstream of the diversion would not drop below 1,320 cfs because of release from Lake Livingston. This provides a "worst-case" scenario analysis as additional flow releases produce the greatest hydraulic stress on the river.

The results provided by a review of **Figures 4-2** and **4-3** below show increase in sediment load at lowest flow; this is due to the impacts of flow releases from Lake Livingston dam to maintain minimum instream flow of 700 cfs. Additional analyses were conducted to provide an estimate of the percent change in sediment load based on the anticipate withdrawal rates and the lower Trinity River flow regime (Baird 2010).

These figures show that the small increase in sediment load from the Lake Livingston releases are less than 0.01 percent of the lower Trinity River sediment budget. For larger flows with no release from Lake Livingston and constant withdrawal rates, the proposed withdrawal from CRPS slightly reduces the downstream sediment load. The largest sediment load reductions for the 400 and 227 MGD scenarios were approximately - 0.2 percent and - 0.1 percent, respectively, compared with baseline sediment load.

**Figure 4-2:**

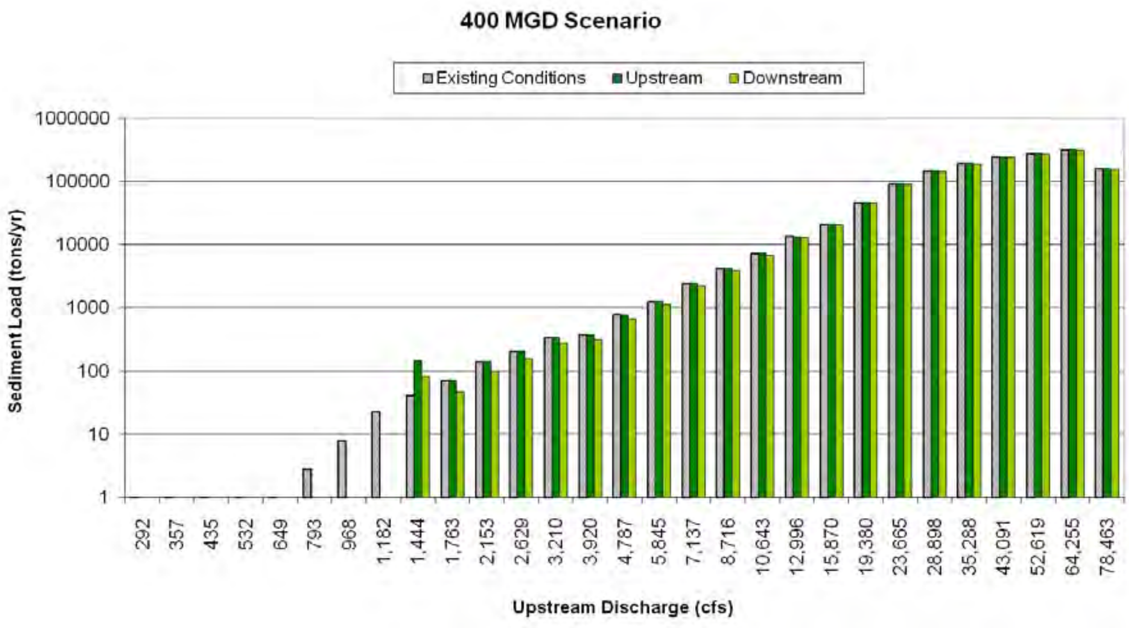
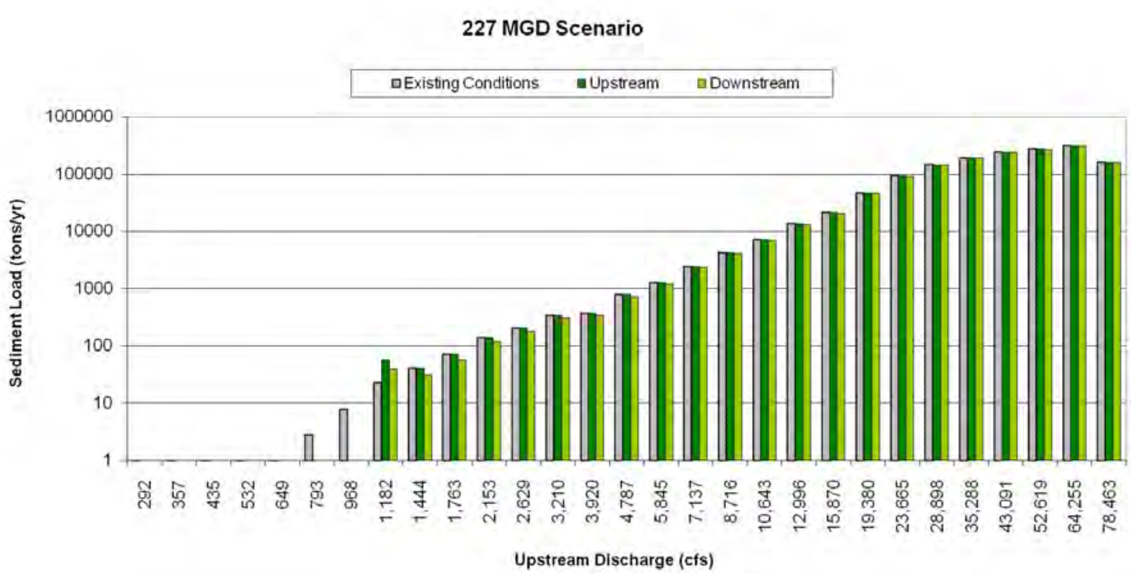



**Figure 4-3:**
**227 MGD Scenario**



#### 4.1.7.3 Alternative 4

Although the proposed pipeline alternatives (Alternatives 4 and 6) would be installed below-grade, the ROW would be contoured and permanently maintained thus permanently affecting the potential for erosion of the land surface. In all cases, grading would occur to minimize erosion to the extent possible after construction. In general, the Alternative 4 facilities would be constructed in a comparable landscape conditions consistent with the surrounding land area in order to minimize effects on aesthetics and to minimize the potential for an increase or change to the potential for sedimentation and erosion. During final design, the exact number and placement of hydraulic flow conveyance structures (siphons or drainage ditches) would be evaluated with the goal of minimizing the potential for localized flooding. For Alternative 4, effects on sedimentation and erosion would be related to withdrawal of Trinity River water and discharge into Lake Houston. With the exception of studies conducted for Alternative 3A that apply to Alternative 4 pertaining to the CRPS and lower Trinity River, no site-specific studies have been conducted to evaluate the potential effects of Alternative 4. Sediment would be generated by withdrawal of surface water from the proposed CRPS, as discussed above for Alternative 3A. Sediment would be managed onsite similar to those described for Alternative 3A.

#### 4.1.7.4 Alternative 6

Although the proposed pipeline alternatives (Alternatives 4 and 6) would be installed below-grade, the ROW would be contoured and permanently maintained thus permanently affecting the potential for erosion of the land surface. In all cases, grading would occur to minimize erosion to the extent possible after construction. In general, the Alternative 6 facilities would be constructed in a comparable landscape condition consistent with the surrounding land area in order to minimize effects on aesthetics and to minimize the potential for an increase or change to the potential for sedimentation and erosion. During final design, the exact number and placement of hydraulic flow conveyance structures (siphons and drainage ditches) would be evaluated with the goal of minimizing the potential for localized flooding. For Alternative 6, effects on sedimentation and erosion would be related to withdrawal of Trinity River water and discharge into Lake Houston. No site-specific studies have been conducted to evaluate the potential effects of Alternative 6 and therefore qualitative analyses are not provided. Sediment would be generated by withdrawal of surface water from the TRPS. Sediment would be managed onsite similar to existing operations.

#### 4.1.7.5 Reduction and Mitigation of Potential Impacts

The preliminary Lake Houston outfall design is illustrated by Section 404 IP Sheet 33. Water level control structures would be designed and constructed along the canal to maintain the water elevation in the canal. These structures are depicted by Sheet 37. The Lake Houston outfall or discharge structure will transition the canal at a concrete drop structure and headwall along Lake Houston's bank. The flow would be conveyed through three 8-foot by 6-foot box culverts which would be diverted 36 degrees to the south of the canal centerline near Lake Houston's bank. The diversion angle was modeled and selected to minimize the effects from erosion and scour at the existing outfall location. The box culverts would be constructed within Lake Houston's banks, and would discharge below the average water surface elevation at that location. The outfall structure would be underwater. The area immediately adjacent to the outfall would be within a concrete basin or apron beneath the existing channel bottom and surrounded by an underwater concrete weir. This basin and weir structure at the outfall to Lake Houston would prevent lake-bottom scouring and erosion. Shoreline protection would also be required to prevent and limit erosion during low water periods. Based on historical low water elevation information and existing conditions, shoreline protection is recommended to be 60 feet upstream from the outfall location and 120 feet downstream from the outfall location. Based on the preliminary findings from the outfall erosion investigation, the outfall was not anticipated to have an adverse effect on the opposite bank or islands located within the existing outfall channel.

During typical Alternative 3A canal flow conditions and canal water elevations, the potential for Lake Houston bed scour is not significantly increased with the projected outfall volumes. However, during a combination of low water levels in Lake Houston and maximum canal discharge rates, sheer stresses within the outfall area could induce localized erosion and scour. The erosion and outfall investigation conducted for Alternative 3A recommended that a permanent shoreline and bathymetric observation program be considered to monitor the outfall for erosion and scour combined with adaptive management procedures to minimize localized environmental effects at the discharge.

For all alternatives, surface grading, excavation filling and soil removal and/or mixing would occur during construction of the LBITP. During operation, eroded soils generated from the sediments present in the water to be removed from the Trinity River would be generated, need to be removed via the sedimentation basin and managed appropriately (stockpiled for future use or disposed of/managed appropriately). Reclamation and the installation of erosion control measures and devices would minimize erosion and the potential for sediment to leave the construction site. Sediment or soil erosion control measures in accordance with the NPDES and TPDES General Permit for Construction Activities would be implemented during the project's construction and operation to minimize discharging or moving stored sediment with storm water runoff into area water bodies, wetlands or the proposed canal. A SWPPP with BMPs would be prepared as part of the LBITP discharge elimination permitting for construction activities. The SWPPP would contain spill prevention and response procedures meeting state and federal agencies requirements. Based on the planned implementation of erosion control measures during construction (e.g., sediment control ponds, diversion ditches, silt fences, straw bales, and re-vegetation measures), the potential for localized soil erosion as a result of the discharge of surface water from the construction site is anticipated to be low to moderate and temporary.

## 4.2 Hydrology

Hydrology addresses the surface water, groundwater and connectivity cycle including precipitation and scientific and engineering studies are conducted in attempts to understand water's occurrence, circulation and distribution, chemical and physical properties, and the reaction between water and the environment including plants and animals. The hydrological cycle describes water's constant movement above, on and below the land surface, and includes water's movement through evapotranspiration, precipitation, surface runoff, sub-surface flow and groundwater pathways. Water's infiltration rate varies with land use, soil characteristics and a rainfall event's duration and intensity. Precipitation rate exceeding the infiltration rate leads to overland flow and possibly flooding. Water reaching streams or bayous via surface runoff and groundwater discharge through seeps or springs eventually moves into Galveston Bay or the Gulf of Mexico, and evaporates to perpetuate the hydrological cycle.

Total flow from drainage basin runoff is calculated by adding together the flow data originating from gauged and ungauged watersheds. Gauged flows are obtained from USGS stream flow records and ungauged runoff is calculated. Ungauged runoff is the sum of the following flow factors:

- Computed runoff, using a rainfall-runoff simulation model, based on precipitation over the watershed
- Flow diverted from streams by municipal, industrial, agricultural and other users
- Unconsumed flow returned to streams

Total surface inflow reaching the Galveston Bay estuary consists of:

| | | |
|---|---|---|
| Surface Inflow | = | (1) Sum over all gauged watersheds (USGS Gauged Flow) |
| | + | (2) Sum over all ungauged watersheds (Modeled Flow) |
| | - | (3) Sum over all ungauged watersheds (Diverted Flow) |
| | + | (4) Sum over all ungauged watersheds (Returned Flow) |

When considering developing the total freshwater balance, evaporation from and precipitation on the water estuary's surface the must be considered:

| | | |
|---|---|---|
| Freshwater Balance = | | Surface Inflow |
| | - | (5) Evaporation from the estuary surface |
| | + | (6) Precipitation on the estuary surface |

Galveston Bay includes a combination of several adjoining bays including Trinity Bay to the northeast, Upper and Lower Galveston Bay to the west, and West and East Bay to the south. These waterbodies drain into the Gulf of Mexico, which is separated from these bays by Galveston Island to the west and the Bolivar Peninsular and High Island to the east. Galveston Bay's hydrology and functioning are directly influenced by physical processes including erosion, sedimentation, tides and currents and man-made features such as ship channels, dikes and other structures. The presence of Galveston Island, a barrier bar system created by long shore currents and depositional processes from the Gulf of Mexico, continues to influence Galveston Bay's hydrology.

Streams in their natural state are dynamic ecosystems that perform many beneficial functions. Natural streams and their floodplains convey water and sediment, temporarily store excess flood water, filter and entrap sediment and pollutants in overbank areas, recharge and discharge ground water, naturally purify instream flows and provide supportive habitat for diverse plant and animal species. By contrast, water supply conveyances are designed to deliver source water to a location where it can be further purified/ treated for delivery to homes and businesses for human consumption. In every way practical, the delivery system concept focuses on quantifiable and measurable water supply flows, and is designed to reduce or eliminate the potential for bacterial contamination, turbidity, and water loss through seepage or infiltration.

Galveston Bay is within the TWDB-established Region H, which has been designated for water planning efforts. Freshwater inflows sources to the bay are a combination of major and minor rivers, local runoff directly into the bay and rainfall on the bay. Freshwater contributions to Galveston Bay include 54 percent from the Trinity River, 28 percent from the San Jacinto River and 18 percent from the local watershed (runoff and creeks) (GBFIG 1995). The 2011 Region H Water Plan incorporates as an Appendix the Environmental Flows Study issued in 2009. Water management strategies identified by regional water plans, including the Galveston Bay and Trinity River upper basin return flows from the Dallas Metroplex (Region C), would help meet state-identified environmental flow criteria for Galveston Bay proposed by TWDB and refined by GBFIG. The flow regime necessary to achieve the maximum harvest (MaxH) environmental flow criteria for Galveston Bay would occur at least 50 percent of the time under the strategies adopted for Region H. The flow regime necessary to achieve the minimum flow required to maintain the bay and estuary salinity target (Min Q-Sal) for Galveston Bay would be achieved at least 75 percent of the time based on water management strategies incorporated into Region H water plans. These environmental flow criteria have been adopted by GBFIG for Galveston Bay.

The study area for direct and indirect effects for hydrologic resources is considered on a watershed basis. The study area encompasses the Region H RWP boundary, the proposed LBITP ROW, CRPS and TRPS locations, the LBITP discharge locations to Lake Houston, and the area of the mitigation property. Hydrologic resources include the following categories:

- Surface water resources and surface water quality
- Lower Trinity River discharges and environmental flows (**Section 4.8**)
- Water supply through water rights permitting and conservation
- Socio-economic issues related to IBTs and hydrologic resources as described in Region H RWP

Natural stream characteristics such as channel forming and reconditioning, gradually varies flow. This contributes to meandering, sediment transport through natural erosion, developing sediment bed-load which contributes to channel stability. Groundwater influenced base flows are missing from a water supply conveyance. The area with direct influence for hydrology includes the watersheds of North Galveston Bay, Lower Trinity River, San Jacinto River, Cedar Bayou, Galveston-San Jacinto Basins that incorporate Goose Creek. The area of direct and indirect effect for hydrology encompasses 100-year flood hazard area, the 500-year flood hazard area. The hydrology cumulative effects study area is the same as the waters of the United States, including wetlands RSA (see **Chapter 5**) and is focused on downstream water rights.

#### 4.2.1.1 Analysis Methods

For Alternative 3A, high resolution aerial remote sensing using Light Detection and Ranging (LiDAR) data collection and processing and use of Arc-Hydro, an extension of ArcMap were used to calculate drainage lines for the area surrounding proposed canal alignment. One-dimensional (1-D) and two-dimensional (2-D) Hydrologic Engineering Center's Hydraulic Modeling System (HEC-HMS) models issued by the USACE were run in parallel mode and were used for the drainage analyses to determine break locations. Sub-basin areas that were intersected or affected by the proposed Alternative 3A alignment were examined through use of the HEC-HMS model.

The proposed Alternative 3A canal may result in altering the duration, intensity, magnitude, location or potential for flood events or changes to overland flow patterns. Prior to inclusion in the Region H RWP in 2010, the effects of withdrawal of 450 MGD from the lower Trinity River for the LBITP were investigated for bay and estuary (B&E) flows through studies conducted as part of the state's water planning program (Senate Bill [SB] 1). The *Environmental Flows Study* (2009) was developed to analyze the effects of the LBITP on B&E flows of the lower Trinity River and Galveston Bay. Based on the SB 1 analyses conducted, the LBITP was in compliance with Galveston Bay Freshwater Inflows Group (GBFIG) target inflows using State Methodology for determining freshwater inflow needs. Under SB 3, as of April 20, 2011 (effective May 15, 2011), the TCEQ adopted environmental flow standards for the Trinity and San Jacinto Rivers and their associated tributaries, and Galveston Bay including Trinity, East and West Bays (30 TAC 298 Subchapter B), as required under SB 3. These environmental flows standards identify target environmental flow goals that were developed to meet a sound ecological environment while considering competing water needs such as the present and future water requirements presented by the Region H RWP (including the proposed LBITP) and adopted as part of the State Water Plan (2011).

A geomorphological and sedimentation study of the lower Trinity River and Lake Houston was conducted by Baird in 2009 for the LBITP. The investigation included sedimentation and geomorphology effects along the lower Trinity River and Luce Bayou at the proposed CRPS and discharge structure due to the proposed diversion and discharge of 450 MGD of water into Luce Bayou near the confluence with Lake Houston.

A hydraulic and sediment transport study was conducted for the Alternative 3A ROW along the Trinity River near Capers Ridge and at the Luce Bayou/Lake Houston discharge location in order to optimize preliminary design for the intake and discharge structures.

Existing state water planning efforts have developed the 2011 Regional Water Plan for Region H, incorporated the results of the SB 3 process into policy and related decisions, and have resulted in the development of studies or dissertations pertaining to regional water management strategies . Man Sueng Han presented a dissertation for Texas A&M in May 2008 titled, *Environmentally-related Water Trading, Transfers and Environmental Flows: Welfare, Water Demand and Flows* that used the TEXRIVERSIM model (and other analyses) to evaluate water interbasin transfers and environmental flow needs.

The study area for direct and indirect effects to hydrology encompasses the proposed LBITP ROW, the lower Trinity River in the vicinity of the proposed CRPS and existing TRPS diversion locations, the three proposed LBITP discharge locations that outfall to Lake Houston, and the area of the mitigation property.

The hydrology cumulative effects study area encompasses the RSA for waters of the United States, including wetlands (**Chapter 5**).

Environmental effects of the LBITP associated with hydrology includes the area of the proposed alternatives within the 300-foot ROW, the lower Trinity River for a distance of approximately 2,000 feet downstream of the CRPS and the TRPS diversion points, within 1,000 feet of the Lake Houston discharge location, and the following watersheds: lower Trinity River, Cedar Bayou, North Galveston Bay, and Galveston-San Jacinto River watersheds.

#### 4.2.1.2 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, no construction activities would occur and there would be no impact or change in baseline conditions related to hydrology. Implementation of No Action would result in potentially adverse effects on hydrology as through time, water supplies in Lake Houston and the San Jacinto River watershed are depleted. Permanent, direct or long-term effects to the Lake Houston and indirectly to groundwater resources would occur under No Action. Groundwater to surface water conversion for water demand and the necessary supplement to increase to San Jacinto River water supplies would not occur. Regional water plans would not be implemented and groundwater supplies would be used to meet water demand.

Subsidence would be expected to continue with detrimental, long-term and likely permanent effects to the region, land use, wetlands loss, flooding and flood hazards. Flooding may be exacerbated in the Region H RWP area, and localized subsidence and flooding in central, western and northern Harris County would continue, gradually increasing in intensity, duration, severity and recovery time as water supplies are increased to meet forecasted population demand. The physical consequences of subsidence resulting in changes to hydrology have been apparent in the Houston metropolitan area where as much as 10 feet of subsidence has occurred.

#### 4.2.1.3 Alternative 3A

Capers Ridge is a natural ridge, approximately 12,000 feet long of variable width, formed as a Trinity River floodplain terrace which exhibits strong relief and, in the vicinity of Alternative 3A intake forms a drainage boundary between the Mud Lake and Gillen Bayou watersheds. Because the CRSP and pipeline would be located along this ridge, along the drainage boundary between watersheds, the proposed facilities would not affect the local area's natural drainage patterns after construction.

The proposed Alternative 3A outfall structure is located on Luce Bayou, a tributary to the East Fork of the San Jacinto River and Lake Houston. The outfall structure is proximate to and upstream from the confluence of Luce Bayou and Lake Houston. Previous studies used numerical modeling to assess the impacts from the proposed outfall discharge on hydrodynamics and the potential for bank erosion and bed scour near the outfall location at Luce Bayou.

Luce Bayou meanders from its headwaters near FM 321 and the channel width ranges from 20 feet to 350 feet in the vicinity of the discharge location. As Luce Bayou flows to the west, the channel becomes narrower upstream from the town of Huffman at the Cleveland Road Bridge (near FM 2100), upstream of Lake Houston. The distance from the proposed outfall at Luce Bayou to Lake Houston is approximately 1.5 miles, and the flow pattern is directly affected by the upstream discharges from the East Fork of the San Jacinto River and the water level (reservoir pool elevation) at Lake Houston. Near the proposed outfall, the Luce Bayou channel is divided by an island into two branches, and the outfall is at the eastern shoreline of the eastern branch of Luce Bayou.

A hydraulic and sediment transport study was conducted for the Alternative 3A ROW for the area along the Trinity River near Capers Ridge and at the Lake Houston discharge location area. Analyses from USGS historical peak flow data collected from the Huffman gauge near the proposed discharge point provides an understanding about potential water level fluctuation in the area. The minimum and maximum water levels near the Alternative 3A discharge point are 40.11 feet and 49.26 feet above MSL, respectively. Similarly, minimum and maximum water levels modeled for the CRPS intake are 16.1 feet and 44.7 feet above MSL, respectively.

Diverting 450 MGD of raw water has the potential to change the lower Trinity River's flow regime, as determined via hydrological analyses using ERDAS and other models conducted under the TWDB's SB 1-3 water planning programs. Wetlands along the LBITP conveyance are primarily affected by precipitation and drainage (overland flow). The proposed Alternative 3A canal would be elevated in places above the existing ground level and in these areas the canal could impede the existing drainage patterns. Withdrawing 230 MGD during Phase I and 450 MGD during Phase II operations would also affect the lower Trinity River's flow regime and indirectly the Galveston Bay estuary. Discharging water to Lake Houston for treatment via Luce Bayou could affect the hydrology of both Lake Houston and Luce Bayou within the San Jacinto River watershed. Wetlands dependent on local hydrology to function and hydrology that affects fish and wildlife habitat could change after the implementation of the LBITP. During low flow conditions, IBT withdrawal from rivers has been demonstrated to have a profound effect on river currents, sediment transport, and possible scour and deposition areas. These effects would primarily be observed when flows in a river are already low. Based on Alternative 3A hydrologic investigations and modeling, the observed and modeled effect on river flow patterns would be limited to low flow conditions and would involve movement of fine grain size sediments in the Trinity River.

The proposed Alternative 3A canal alignment traverses through 26 of the 28 sub-basins identified through LiDAR data analyses. The Alternative 3A canal would have berms on either side which could potentially serve as barriers to the existing drainage pattern. These effects will be partially offset through hydrological design features including below-grade siphons and drainage structures to maintain existing surface hydrology and drainage.

The proposed Alternative 3A canal would discharge into Luce Bayou at the confluence of Lake Houston. The canal would discharge below the OHWM through three 6-foot wide by 8-foot long box culverts. Through sedimentation and erosion analysis studies and modeling, it was determined shoreline erosion protection would be needed at the discharge point. Approximately 975 cubic yards of riprap would be placed below the OHWM. Constructing the concrete headwall and placing erosion protection would directly and permanently impact approximately 0.30 acre below Luce Bayou's OHWM at the confluence with Lake Houston. Placing riprap and excavating material would result in localized permanent direct impact to area sediments in the Luce Bayou. Stabilizing these sediments and the shoreline would ultimately provide a positive benefit to the area proposed for construction by localizing hydrological effects to the lower Trinity River caused by proposed construction and operation of the build alternative.

#### 4.2.1.4 Alternative 4 and Alternative 6

Diverting 450 MGD of raw water from the Trinity to San Jacinto River basin has the potential to change the lower Trinity River's flow regime, as determined via hydrological analyses using ERDAS and other models conducted for the proposed LBITP under the TWDB's SB 1-3 water planning process. The proposed Alternative 4 and 6 pipeline conveyance would change the landscape along the 300-foot wide water line easement that would locally permanently affect and impede the existing surface drainage patterns. The landscape would change as access roads and a linear bermed alignment would provide evidence of the buried location of the two, below-grade 9-foot diameter water pipelines.

Drainge ditches on either side of the pipeline easement and access road could potentially serve as barriers to the existing drainage pattern. Withdrawal of 230 MGD of water during Phase I and 450 MGD of water during Phase II operations would also affect the lower Trinity River's flow regime, and ultimately Galveston Bay. Discharging water to Lake Houston for treatment could locally affect the hydrology of Lake Houston and the San Jacinto River watershed. Wetlands along the proposed LBITP conveyance route are primarily affected by precipitation and drainage (overland flow). The wetlands dependent on local hydrology to function and for the environmental needs of fish and wildlife could also be influenced by changes in hydrology due to implementing the LBITP.

Site-specific analyses related to hydrology and surface water drainage or flooding have not been conducted for Alternatives 4 and 6. However, it can be presumed that specific hydrologic investigations would be performed during preliminary and final design in order to quantify/characterize local hydrologic alterations and the means to reduce these effects. Impedances to changes in surface water drainage would be minimized to the extent possible to maintain overland flows. Ditches or other flow restoration and management features would be designed and implemented to minimize potential overland and surface drainage effects related to the LBITP.

In general, based on specific studies conducted for river IBTs, water withdrawals during low flow conditions has been demonstrated to have a profound effect on river currents, sediment transport, and possible scour and deposition areas. For the LBITP, these effects would primarily be observed when flows in a river are already low. Based on Alternative 3A hydrologic investigations and modeling, and assuming that similar river conditions exist along the lower Trinity River at both pump station locations, it would be expected that the effects to flow patterns would be limited to relatively infrequent flow conditions, and would involve movement of fine grain size sediments.

The proposed Alternatives 4 and 6 pipelines would discharge into Lake Houston and it would be expected that the discharge at Lake Houston would be designed to minimize local hydrologic effects. Similar to Alternative 3A, the two 9-foot in diameter pipes would likely discharge into Lake Houston below the OHWM through box culverts and that shoreline erosion protection would be needed at the discharge point. Engineering studies conducted during final design for Alternatives 4 and 6 would allow for the development of an optimum design of the shoreline protection structures that may include placement of riprap, headwall construction, lake or river bottom excavation, sheet pile installation efforts, dewatering, and related infrastructure installation along the eastern shoreline of Lake Houston at the proposed discharge locations for Alternatives 4 and 6. Stabilizing the sediments of the shore and bottom of Lake Houston would be needed and design efforts would seek to minimize permanent erosion and sedimentation affects caused by proposed construction and operation of these alternatives.

#### 4.2.1.5 Reduction and Mitigation of Potential Impacts

The potential hydrological effects related to constructing and implementing LBITP are not, by themselves, considered to result in regional large-scale, permanent long-term effects. LBITP would not cause substantial changes in stream flow on the Trinity River or Lake Houston compared to existing conditions since, in general, average flow rates within the lower Trinity River would change substantially during high or medium flow regimes. During low flow conditions, hydrological effects are anticipated to be significant during low flow periods as up to 450 million gallons of water per day are removed from the lower Trinity River.

The Public Notice for Permit Application No. SWG -2009-00188 provided a review for the Section 404 IP Sketches (Sheets) numbered 1 through 44. The proposed siphon locations are provided as shown on Sheets 12-32 (note “siphon” call-outs). Sheet 38 provides the cross-section and plan view for the siphon structures, which eliminate hydrology changes and provide opportunities for safe wildlife crossings.

A drainage area map, drainage lines, and catchment area boundaries were determined based on LiDAR and the limited topographical information available during the project’s preliminary engineering. Throughout the project alignment, drainage breaks were inserted along the canal to permit drainage across Alternative 3A to maintain existing drainage patterns where possible and practical. The process for developing the project drainage, hydrology, and hydraulics is described in detail in the following paragraphs.

Arc-Hydro, an extension of ArcMap, was used to calculate drainage lines for the area surrounding the proposed alignment using topographical information from a digital elevation model (DEM). Sub-basin area boundaries were delineated from these drainage lines using a minimum 100-acre basin size. To determine drainage break locations, only sub-basin areas intersected or affected by the proposed alignment were examined in the HEC-HMS model.

The velocity for each sub-basin was selected from the TxDOT Hydraulics Manual. The selected velocity was based on the weighted average of the Manning's n-value for each sub-basin ranging from 0.1 to 0.15. The travel time for sheet flow and the quotient of drainage flow path and velocity were converted into minutes to calculate the concentration time. The SCS lag time calculation, $T_{lag}$ =0.6*Tc, was used for each sub-basin and input into HEC-HMS. The model performed simulations for the 1 percent and 50 percent Annual Exceedance Probability (AEP) storm events.

For the project roadways hydrology, the roadway drainage criteria from Liberty County's subdivision regulations were used for roadway drainage. The 2-year storm event was selected for these agricultural areas, as this is consistent with typical road side ditch design capacity. The event duration is the primary concern, compared to the depth of flooding for agricultural or undeveloped areas.

To model the proposed conditions, one-dimensional and two-dimensional models were used in parallel.

- A hydrograph representing rainfall was introduced in a two-dimensional overland flow model, which models shallow sheet flow behavior. From this model, a stage hydrograph was obtained at the downstream ROW for each crossing.

- In the one-dimensional model, each crossing was modeled as a separate reach. Under existing conditions, cross-sections along the reach represented the elevation data at the upstream and downstream ROW and the canal's centerline. Under proposed conditions, the centerline cross-section was replaced with an inline structure containing a culvert and a weir representing the crossing structure. The watershed on the upstream side was modeled by a storage area with an elevation-volume curve obtained from the DEM and connected to the reach as the upstream boundary.

HEC-RAS Version 4.0 was used to model the proposed canal. The model was setup for unsteady state modeling of time varied flow rates. A runoff hydrograph was introduced to the upstream storage area and the stage hydrograph obtained from the two-dimensional model was applied as the downstream boundary condition. The resulting stage hydrograph measured in the storage area from the model was compared to the existing and proposed conditions to measure project impacts. Initial demands indicate an expected 230 MGD or 356 cfs flow rate after the Alternative 3A canal is constructed. This interim flow rate will result in lower velocities through the siphons. The typical measured impact on the proposed upstream side for the 100-year event was an increased depth of 3 to4 inches for 5 to16 hours. One 10-foot by 7-foot and one 5-foot by 7-foot flow control barrel would be recommended for the 356 cfs interim flow. This flow rate provides an approximate 3.4-fps velocity within the siphon.

Flow depth within the Alternative 3A canal varies between seven and eight feet, depending on the location in relation to water level control gates, existing roadways and siphon crossings. The normal water level depth in the canal is approximately 7.3 feet. A typical 10-foot canal depth provides an average 2.7-foot freeboard flow. Several reaches along the canal where the roadway and siphon crossing are spaced fairly close together, will cause incremental head losses between the structures to raise the flow depth in the canal to approximately eight feet. In these reaches, the canal would be constructed to an 11-foot depth, providing the recommended 1.33 foot freeboard flow depth.

The Alternative 3A outfall structure into Lake Houston is assumed to be three 8-foot by 6-foot box culverts. The approximately 640-foot long culverts have 28.8 feet of fall from the 62.8 inlet elevation to the 34.0 outlet elevation. The outlet is submerged below Lake Houston's 43.5-foot normal pool elevation. By submerging the outfall, a hydraulic jump is forced to occur within the culverts, reducing the discharge velocity into the lake. The velocity is further diminished by discharging the flow into a concrete stilling basin. The submerged basin has a top-of-wall elevation of approximately 39.5 or 1.5 feet above the Lake bed elevation at the outfall. The top-of-the wall functions as a submerged weir with an effective length of approximately 90 feet. The stilling basin will allow the discharge to swell up within it and uniformly distribute into the lake.

The culvert entrances for Alternative 3A are designed to minimize entrance losses by providing flared wing walls and beveled top edges. The culverts are at a very steep slope, and critical depth is achieved within the culverts. This combined with the submerged outfall forces a hydraulic jump to occur within the culverts. The culvert's entire capacity is not used where water is flowing at a critical depth. The entrance will be designed so open channel flow occurs within the culvert upstream from the hydraulic jump to prevent air from being trapped within the culvert.

When the Alternative 3A canal is at ultimate capacity, approximately 975 acre-feet of water is contained within the LBTP's canal portion. With a zero flow condition, approximately 600 acre-feet of water remains in the system stored behind the water level control gates.

The Alternative 3A conceptual design included drainage ditches paralleling the canal alignment along both sides. The ditches will drain toward the low point in the sub-basin, and will be interconnected by a culvert(s) crossing the canal alignment. The canal will be siphoned below the culvert crossing, allowing for extreme events to flow over the maintenance road. Less extreme events will be able to pass through the culvert at each crossing. The parallel ditches will act as spreader ditches, allowing flow to leave in a sheet flow pattern where applicable. A majority of the alignment does not have significant existing drainage facilities for collecting existing runoff. The proposed ditches will have a sufficient depth for allowing the cross culvert to be below natural grade and provide adequate cover. However, this design will result in some ditch flow lines being below the natural grade at outfalls, resulting in the ditches remaining wet for extended periods. While the model calculations are correct for the assumptions used in this report, changes from these original assumptions will occur as new information becomes available. Further hydraulic analysis will be required in LBTP's final design to verify the effects of the actual roadway crossing designs, siphon lengths, water level control gates design and location, etc.

Eighteen siphon structures would convey Alternative 3A water in the canal below the ground surface through concrete box culverts. These siphon structures would maintain local hydrologic and drainage systems by allowing sheet flow to be conveyed overland. The surface expression for these drainage conveying siphons include ditches, swales and 200-foot long by 300-foot wide open grassy areas. These siphon structures would not be located at pipeline, utility easements, or roadway crossings. They would allow wildlife safe passage across the proposed 23.5-mile long canal conveyance structure. The siphon structures would be covered with grass and primarily located at ground level with a small swale to allow for drainage across the canal ROW. The canal alignment and siphon locations would be fenced with barb-wire along Alternative 3A's ROW boundaries. The siphons are proposed to be located along the canal alignment, in undeveloped areas at points determined through hydraulic analyses to require overland flow conveyance to avoid impacts to local hydrology. The proposed combination siphon and wildlife crossing features will be along the proposed Alternative 3A's 23.5-mile long ROW through Liberty County.

The Alternative 3A raised canal will impede natural overland and channelized flow drainage paths. To remedy this, a series of siphons in conjunction with collector ditches and culverts will be used along the alignment ROW. Proposed crossings include culvert-weir structures. The culverts are sized to pass flows up to and including the 50 percent AEP storm event without overtopping the canal maintenance road. For larger events, a shallow flow depth is allowed to overtop the roadway to minimize increased ponding depths upstream from the canal. Flow from the culvert and weir will be collected in the downstream ditches and spread as previously described.

The Alternative 3A canal would be designed to convey 774 cfs, maintaining a water flow level in the canal between seven and eight feet. Seven water level control gates are proposed to limit the drop in water level to a maximum of four feet when the flow rate is reduced below 774 cfs.

LBITP's canal design criteria mitigates against vegetation growth within the canal by developing a channel cross section which maintains water velocity at 2 feet per second (f/s) to limit plants ability to take root in the canal. Much of the canal will experience 5 f/s velocities, which will require hardened (concrete) lining or armoring the canal. The canal's design flow depth (7 to 8 feet) will limit sunlight penetration, thus eliminating the potential for aquatic plant photosynthesis (AECOM 2011).

The lower Trinity River segment in the vicinity of the LBITP is not used for commercial navigation and, therefore, no impacts to regional commercial shipping would occur. See **Section 4.7** relative to potential impacts to recreational boating and canoeing. As with other elements constructed within the lower Trinity River, short-term temporary increases in suspended sediment concentrations, turbidity, and sediment deposition would occur from project-related disturbance. Short-term temporary increases in suspended sediment concentrations, turbidity, and sediment deposition would be minimized by implementation of erosion control measures. During the inactive periods, high flows would subject stockpiled materials to erosion. Flow paths between material stockpiles, construction area, and the haul road would promote additional erosion, turbidity, and sedimentation between the embankments and into the river during overbank flows. These flow and water quality impacts would be short-term in nature. Because of the potential for these impacts from excavation, stockpiling, and equipment tracking during wet periods, monitoring and mitigation may need to be considered. Construction effects and the long-term presence of the LBITP structures present in the lower Trinity River may induce channel migration although additional studies and modeling would be performed during final design to develop appropriate long-term mitigation for channel migration.

Upstream or downstream effects could occur; old channel scars occur in both directions. A relatively straight reach of the river is downstream and with adequate foundations, the proposed bridge and embankment would help anchor the channel. These factors likely would minimize downstream bank shifting and channel migration. The river is strongly meandering upstream of the crossing. Flood flows through Mud Creek and circulation patterns near Capers Ridge of the lower Trinity River during flooding may encourage additional bar and bank shifts in meanders and effects on opposite and adjoining properties owned by the USFWS (Trinity River NWR parcels near both the proposed CRPS and the existing TRPS). Additional sediment transport, turbidity, and deposition could result and these effects could vary widely in their intensity and timing and hence potential effects.

The lower Trinity River is dominantly a sand-bed channel (Baird 2010). Based on general sand sizes and flocculation of smaller particles in the flow, suspended sediments from construction during low flows likely would settle out within a mile or so downstream of the proposed channel crossing. For example, with a flow depth of approximately 4.5 feet and a mean downstream velocity of approximately 1.2 to 1.5 f/s, a small sand particle will settle out of reasonably calm flow in approximately 100 feet or less. Re-suspension could increase that distance, but it gives a general idea of a potential downstream impact area for sands.

Under the same conditions, dispersion and settling of clay aggregates from the water column typically would occur over a much greater river distance. Depending on water chemistry and a concentration criterion, silts and clays in that flow may require 0.5 mile or more to settle out to the criterion or to a background concentration. Changes in flows, turbulence, and re-suspension would modify those settling distances as well as background concentrations. Nonetheless, increases in suspended sediment concentrations, turbidity, and sediment deposition would occur from project disturbance in and adjacent to the river, generally on the order of the distances mentioned here. These water quality changes would be short-term in nature. Because of the potential for channel mitigation, sedimentation, and turbidity impacts to a waterbody that is a candidate "Ecologically Significant River Segment", additional mitigation is being considered as discussed in **Chapter 6** (Baird 2010 and Baird 2012).

## 4.3 Surface Water Resources and Quality

Water is an essential resource, basic to human survival, economic growth and the natural environment. Water conservation requires using water resources efficiently in all actions involving significant water use or significantly affect water availability for alternative uses including opportunities to reduce demand and improve efficiency to minimize new supply requirements. Actions affecting water quantities are subject to Congressional policy, as stated in Section 101(g) of the Clean Water Act which provides the authority of states to allocate water quantities shall not be superseded, abrogated, or otherwise impaired. The State of Texas protects water quality through several regulatory programs and agency interactions between the TCEQ, EPA, and USACE. Included in these programs are rules and regulations administered primarily under the Federal Water Pollution Control Act (CWA), the Safe Drinking Water Act, and the Texas Clean Rivers Act. Major aspects of water quality regulation and management in the state are set forth in the Texas Administrative Code and include the following:

- Designation of waterbody segments and their associated beneficial uses
- Assigning water quality standards for the designated uses in general and for waterbody segments specifically
- A formal process for evaluation and modification of standards applied to specific waterbodies, including temporary variances
- An anti-degradation policy administered through a tiered approach
- Control of pollutants in storm water
- Protection of drinking water
- A tiered approach to water quality certification with respect to dredge and fill activities in waters of the United States
- Monitoring and management of water quality at watershed or river-basin scales, through agency agreements (i.e., Cedar Bayou Watershed Protection Plan being developed by HGAC)

### 4.3.1 Surface Water Resources

For surface water resources, potential direct impacts from the proposed project generally would include changes to the surface water flow regime and water quality effects on Lake Livingston, the lower Trinity River downstream of Capers Ridge and downstream of the existing TRPS, within the San Jacinto River watershed including Luce Bayou, Lake Houston, Cedar Bayou and their floodplains, and indirect effects to Galveston Bay and its estuaries. **Figure 4-4**, **Figure 4-5**, **Figure 4-6** identifies the location of watersheds and mapped boundaries based on the National Hydrography Dataset (NHD) flowlines dataset published by the U.S. Geological Survey.

Construction and resultant modifications would affect surface water features such as floodplains, creeks, ponds, bayous, and perennial and intermittent streams, vegetation and habitat dependent on surface water sources (riparian habitat and bottomlands). The proposed LBITP could also cause long-term, permanent and potentially beneficial effects to surface water quality within the project area. Indirect impacts potentially would include the effects of water discharges or withdrawals on Lake Livingston and the lower Trinity River and resultant discharge of Trinity River water to Lake Houston. Indirect long-term permanent affects of these actions could affect aquatic habitat in the project area or cause indirect effects to ecological, floodplain or scenic values, to wetlands hydrology, and on freshwater instream flows and environmental flows to Galveston Bay and its estuaries. The proposed IBT could potentially contribute to existing cumulative effects on the wetlands and waters of the United States RSA and the RSA established for floodplains for the three proposed action alternatives (**Chapter 5**).

Site-specific analyses related to surface water resources have not been conducted for Alternative 4 and Alternative 6. However, since the permitted diversion amount from the lower Trinity River would be the same for all three alternatives, direct effects to Lake Livingston, the lower Trinity River, and Lake Houston would be similar although, for Lake Houston, the discharge location would vary. However, it can be presumed that specific water resource investigations would be performed as needed to minimize environmental effects to surface water during final engineering design. Studies would be conducted in order to quantify and characterize local surface water alterations and to identify the means to reduce these effects. Impedances to or changes of surface water drainage would be minimized to the extent possible. Project-related effects on overland flows and floodplain resources would be minimized, likely incorporating siphon and drainage structures similar to those identified for Alternative 3A. Ditches or other flow restoration and management features would be designed and implemented to minimize potential surface water quality effects related to the LBITP.

In general, based on specific studies conducted for river IBTs, water withdrawals during low flow conditions has been demonstrated to have a potentially significant effect on river currents, surface water quantity and quality, sediment transport, and may result in an increase to river channel scouring and sedimentation as existing sand or point bars expand or migrate. For the LBITP, these effects would primarily be observed when flows in a river are low and when reservoir levels are low. Based on Alternative 3A hydrologic investigations and modeling, and assuming that similar river conditions exist along the lower Trinity River at both proposed pump station locations, it would be expected that direct effects of the LBITP would occur during low flow conditions and would be relatively infrequent.

With respect to the important resource values recognized along the lower Trinity River in the Nationwide Rivers Inventory (NPS 2010), and the ecological importance of the Luce Bayou segment identified by TPWD (TWPD 2009b), and with the identification of Cedar Bayou as being important to the Galveston Bay system and other wildlife resources at its confluence as well as concerns related to potential impairment under Section 303(d), potential hydrologic impacts are discussed in **Section 4.2**. Potential impacts to “waters of the United States, including wetlands” are discussed in **Section 4.5**. Other resource considerations for these resources including biological functions, aesthetic (visual) values, are analyzed in EIS subsections specific to those resources. LBITP construction for all proposed alternatives would take place in the lower Trinity River during the low-flow season, which generally occurs in late summer and fall. The proposed location of the CRPS and the existing TRPS is on the downstream part of a meander sequence, and upstream of a reasonably straight river reach.

### 4.3.1.1 No Action

The proposed and existing LBITP pump station intake structures are located within the lower Trinity River watershed. The proposed LBITP discharge structures are located within the San Jacinto River watershed more specifically within the surface water body created by the impoundment of the East and West Forks of the San Jacinto River (i.e., Lake Houston). The lower Trinity River and San Jacinto River basins discharge into Galveston Bay.

Under No Action, the LBITP would not be constructed and other water management strategies may need to be implemented to meet available water demands. Groundwater supplies may need to be used to address the projected shortfall in available water supply. In these cases, surface and groundwater resources would be used to the maximum amount possible even as these strategies tend to result direct, long-term harm to water quality and available water quantity as well as significant cost for implementation and management.

### 4.3.1.2 Alternative 3A

To meet the projected water demand from Lake Livingston and to provide the flow requirements from the CRPS diversion point and the TRPS, the water amount impounded for flood storage may be released under existing operating rules for Lake Livingston. This would result in a net positive effect, as peak flood flows would be slightly attenuated, minimizing flood damage and the resultant stream scour would cause geomorphologic changes downstream from the Lake Livingston reservoir.

The drainage basin for Lake Houston is 2,800 square miles. Lake Houston is approximately 8.5 miles long and 1.5 miles wide, and the Lake's main body is located between the confluence of the East and West Forks of the San Jacinto River and the downstream earth-filled dam with a 3,160-foot concrete spillway and embankment sections that total 12,100 feet in length. The spillway crest elevation is 44.5 feet above mean sea level (NGVD 29). Lake Houston's average depth is 12 feet with a maximum depth of about 50 feet near the dam (USGS 2000).

LBITP operation would directly and permanently affect Lake Houston by importing water from the Trinity River. At the same time, increased water demands and associated withdrawals would generally result in lower Lake Houston water level elevations. However, low water levels or changes approximately 0.5 foot below the normal pool elevation are typically recognized as a problem condition for Lake Houston that should be avoided, according to the Applicant's operations staff. LBITP's operation goal is to maintain the Lake Houston's water level consistent with existing conditions. Increased water demand from the Lake Houston intake would result in an increased low lake level frequency, if water delivery from the LBITP would not be properly coordinated. Meeting water needs with additional supply diverted from the Trinity River during critical low flow conditions would address the lake level effects to a great extent. However, water may not be diverted from the Trinity River via LBITP to maintain water levels in Lake Houston. The water rights permit governing CRPS' operation does not allow long-term water storage in Lake Houston. Therefore, diversions from the Trinity River must be limited to meet the daily water demands at the North East Water Purification Plant (NEWPP). When Lake Houston overflows at the spillway dam due to an inflow rate exceeding its demand, for all alternatives considered, the LBITP would cease operation.

To examine the worst-case scenario regarding lake level changes that may occur in the future, Lake Houston water levels were estimated under extreme conditions:

- No inflow from either LBITP or the San Jacinto River (Scenario 1)
- Maximum water demands from Lake Houston in Year 2040 (Scenario 2)

In Scenario 2, Lake Houston water levels would drop 0.5-foot from the lake level's 44.5-foot MSL full condition in approximately 3.6 days. Lake Houston water levels would continue to subside, and would reach a 1-foot drop after approximately seven days of discontinued LBITP operations combined with maximum water demand from Lake Houston. Under some scenarios, operations associated with the water diversion from CRPS may be modified to achieve other goals. A special operational condition would exist when flow is spilled over the Lake Houston dam so LBITP would not continue to operate. In addition to LBITP shutting down due to high flows in the San Jacinto River, high flows in the Trinity River may also result in a need to forego pumping for a limited duration.

During drought conditions, operation of Lake Livingston would require special operational rules. When an adequate stream flow level or stage in the Trinity River is not enough to allow CRPS operation, additional releases from Lake Livingston would be made to allow adequate water diversion for Alternative 3A. Houston's senior water rights allow water impounded by Lake Livingston to be used to meet their allowed diversion amount. Downstream from the CRPS, junior water rights and diversion permits that operate under a run-of-river authorization may not be allowed to divert water from the Trinity River during low flow conditions. A run-of-river permit means users may divert water only when stream flow levels are sufficient. In these cases; the permit holder or user may not use water which has been legally stored or impounded and released. Water released from storage is not available to run-of-river permit holders. Junior water rights are subject to an appropriation of water by date of permit issuance. Houston's water rights are the most senior in the Trinity River basin. The most senior water rights are served first during low flows, with domestic and livestock uses superior to other appropriated rights. Water rights are suspended or curtailed by priority date, with the most recently issued—or junior—priority users suspended before senior water rights in a river basin or area (see **Table 4-4**).

**Table 4-4:**
**Trinity River Junior Water Rights**

| Owner Name | Diversion Amount Value | Priority Date (Year) | Acreage | Reservoir Name | Stream Name | County |
|---|---|---|---|---|---|---|
| Chambers-Liberty County Navigation District | $2,147.00 | 1971 | | Lake Anahuac | Trinity River, Turtle Bayou, Trinity Bay | Chambers |
| Chambers-Liberty County Navigation District | $30,000.00 | 1971 | | Lake Anahuac | Trinity River, Turtle Bayou, Trinity Bay | Chambers |
| Jett Hankamer & Sons | $710.00 | 1967 | 223 | | Whites | Chambers |
| Weldon Alders | | 1984 | | | Big Caney Creek | Liberty |
| Eileen Fowler Attorney Et Al | | 1966 | | | Mill Creek | Liberty |
| Trinity Plantation Inc. Et Al | $1,932.00 | 1969 | 870 | | Menard | Liberty |
| A G Services Inc | | 1979 | | | Gaylor Creek | Liberty |
| Knights Forest Prop Owners | | 1980 | | | Greens Creek | Liberty |
| Lakecroft Inc | | 1979 | | | Long John | Liberty |
| Price & Ellen Daniel Trustee | | 1968 | | | Lake Bayou | Liberty |
| Floyd A Wenzel & L S Sodolak | | 1980 | | | Trinity River | Liberty |
| George W Maxwell | $395.00 | 1960 | 290 | | Cow Island | Liberty |
| George W Maxwell | $805.00 | 1960 | | | Cow Island | Liberty |
| Donald R Maxwell Et Al | $172.25 | 1967 | 65 | | Cow Island | Liberty |
| A Reese Brown | $640.00 | 1975 | 600 | | North Fork Long Island | Liberty |
| Herbert Oreschnigg | $1,550.00 | 2002 | 465 | Reservoir 1 & Reservoir 2 | Long Island Bayou (Marsh Branch Of Long Island Bayou) | Liberty |
| Herbert Oreschnigg | | 2002 | | Reservoir 1 & Reservoir 2 | Long Island Bayou (Marsh Branch Of Long Island Bayou) | Liberty |
| Herbert Oreschnigg | | 2002 | | Reservoir 1 & Reservoir 2 | Long Island Bayou (Marsh Branch Of Long Island Bayou) | Liberty |
| Weldon Alders | $1,050.00 | 2003 | 300 | North Reservoir | Long Island Bayou | Liberty |
| Weldon Alders | | 2003 | | South Reservoir | Long Island Bayou | Liberty |
| Trinity County Regional Water Supply System | $5,097.00 | 1980 | | Lake Livingston | Trinity River | Polk |
| City Of Trinity | | 1980 | | Lake Livingston | Trinity River | Polk |
| City Of Groveton | | 1980 | | Lake Livingston | Trinity River | Polk |
| Glendale Water Supply Corporation | | 1980 | | Lake Livingston | Trinity River | Polk |
| Riverside Water Supply Corporation | | 1980 | | Lake Livingston | Trinity River | Polk |
| T E Duke | $400.00 | 1982 | | | Menard | Polk |
| Property Owners of Ace Tx Inc | | 1985 | | Lake Connie Jean | Williams Creek | Polk |
| Property Owners of Ace Tx Inc | | 1985 | | Lake Edna | Spring Branch | Polk |
| The Nature Conservancy | | 1969 | | | Choates | Polk |
| Wiggins Land Company | | 1979 | | | Choates | Polk |
| Wiggins Land Company | | 1978 | | | Dry creek | Polk |

| Owner Name | Diversion Amount Value | Priority Date (Year) | Acreage | Reservoir Name | Stream Name | County |
|---|---|---|---|---|---|---|
| Mozelle Pixley | | 1975 | | | Black Creek | Polk |
| Dixie Land Corp | | 1975 | | | Turner | Polk |
| Holiday Lake Estates Club Inc | | 1969 | | | Sally | Polk |
| Lakeside Village Subdivision Maintenance Co. | | 1985 | | | Crooked Creek | Polk |
| Wiggins Land Company of Texas | | 1981 | | | Coley Creek | San Jacinto |
| Howard T Harstad | | 1976 | | | Schofield | San Jacinto |
| Mitchell Development Corporation | | 1979 | | | Trinity River | San Jacinto |
| Woodland Tracts Inc | | 1974 | | | Coley Creek | San Jacinto |
| Lake Waterwheels Property Owners | | 1966 | | | Big Creek | San Jacinto |

#### 4.3.1.3 Alternative 4

In general, based on specific studies conducted for river IBTs, water withdrawals during low flow conditions has been demonstrated to have a potentially significant effect on river currents, surface water quantity and quality, sediment transport, and may result in an increase to river channel scouring and sedimentation as existing sand or point bars expand or migrate. For the LBITP, these effects would primarily be observed when flows in a river are low and when reservoir levels are also low. Based on Alternative 3A hydrologic investigations and modeling, and assuming that similar river conditions exist along the lower Trinity River at both proposed pump station locations, it would be expected that direct effects of the LBITP would occur during low flow conditions and that these would occur relatively infrequently.

#### 4.3.1.4 Alternative 6

In general, based on specific studies conducted for river IBTs, water withdrawals during low flow conditions has been demonstrated to have a potentially significant effect on river currents, surface water quantity and quality, sediment transport, and may result in an increase to river channel scouring and sedimentation as existing sand or point bars expand or migrate. For the LBITP, these effects would primarily be observed when flows in a river are low and when reservoir levels are also low. Based on Alternative 3A hydrologic investigations and modeling, and assuming that similar river conditions exist along the lower Trinity River at both proposed pump station locations, it would be expected that direct effects of the LBITP would occur during low flow conditions and that these would occur relatively infrequently.

#### 4.3.1.5 Reduction and Mitigation of Potential Impacts

TRA's Lake Livingston staff operate the lower Trinity River water system in conjunction with staff at the TRPS and at Lake Wallisville to maintain river inflow to meet downstream water demands. Releases from Lake Livingston occur to allow the existing TRPS to remove the amount permitted under existing water rights. A similar operational scheme would be implemented for Alternative 3A to meet demands at the CRPS diversion point. Flows between CRPS and the existing TRPS, and flows downstream from TRPS are currently controlled by the pumping operations at the existing TRPS and release of impounded water from Lake Livingston. Flows downstream from CRPS would be maintained to match or exceed the minimum levels currently experienced in the Trinity River, and be controlled by the demand at the existing TRPS. Releasing impounded water from Lake Livingston would allow for the permitted water withdrawal at the CRPS and the existing TRPS diversion points.

CRPS pump operations would be supervised and managed from the existing Applicant-owned Lynchburg Pump Station. The CRPS pumping rate would be based on: 1) Lake Houston water level elevations; 2) water production rates at NEWPP; and, 3) Lake Houston water demands. Houston's water-rights budget will also have to be monitored and factored into the CRPS pumping rate. The Applicant's operations managers at the Lynchburg facility would advise CRPS operators what their daily pump rate should be. CRPS operators would operate their pumps at that specified pumping rate to meet water demand and operational goals. All CRPS equipment would be controlled, operated and maintained by the Authority's personnel stationed at the CRPS.

As an example of Texas water law priority doctrine, in January 2012, the TCEQ recognized drought conditions had continued across the state and, consistent with previous water-rights holders communications, implemented water rights administration on a priority basis in 2012. During that time period, the TCEQ notified certain junior water-rights holders that their right to divert water would be immediately suspended. The suspended water rights included those with a specific priority date and term in order to protect public health and welfare. No suspensions occurred for those water rights allocated to municipal uses or for power generation. Land owners with property adjacent to watercourses were also allowed to continue to divert water for domestic and livestock use as part of their inherent riparian water rights. In addition, the TCEQ asked all water rights holders to take steps to conserve water, implement their drought contingency plans and prepare for additional suspensions or curtailments should drought conditions persist (TCEQ 2012; http://www.tceq.texas.gov/news/releases/010912DroughtLittleSandy).

### 4.3.2 Surface Water Quality

The State of Texas protects water quality through several regulatory programs and agency interactions between the TCEQ, EPA, and USACE. Included in these programs are rules and regulations administered primarily under the Federal Water Pollution Control Act (CWA), the Safe Drinking Water Act, and the Texas Clean Rivers Act. Major aspects of water quality regulation and management in the state are set forth in the Texas Administrative Code and include:

- Designation of waterbody segments and their associated beneficial uses
- Assigning water quality standards for the designated uses in general and for waterbody segments specifically
- Rules governing standards for low-flow conditions and mixing zones
- A formal process for evaluation and modification of standards applied to specific waterbodies, including temporary variances
- An antidegradation policy administered through a tiered approach
- Control of pollutants in storm water
- Protection of drinking water
- A tiered approach to water quality certification with respect to dredge and fill activities in Waters of the U.S.
- Monitoring and management of water quality at watershed or river-basin scales, through agency partnerships.

### 4.3.2.1 No Action (Surface Water Quality)

Increased groundwater usage, including expanded use of groundwater, interim groundwater, and new groundwater wells, is not expected to have significant environmental effects with respect to No Action on surface water quality. Groundwater within the study area is generally of good quality and available at the point of use. Increases in well pumping will also contribute to return flows potentially benefiting surface water quality. The return flows will increase in proportion to increased groundwater use and significantly contribute to flows into Galveston Bay. Increased and interim groundwater pumping in the region will continue to be monitored by groundwater regulatory agencies since excessive pumping can lead to land subsidence and exacerbate flooding and drainage problems.

Under No Action, the Region H area would need to increase their efforts at water conservation, including municipal, industrial, and agricultural conservation. These changes may have both positive and negative impacts on surface water quality. Water that is being processed through a wastewater treatment plant typically has acquired additional dissolved solids prior to discharge to the waters of the state. Conventional wastewater treatment reduces suspended solids, but does not reduce dissolved solids in the effluent. Water conservation measures will reduce the volume of water passing through the wastewater plants without reducing the mass loading rates (a 1.6 gallon flush carries the same waste mass to the plant that a 6-gallon flush once carried). These effects may result in slightly increased conservative contaminant loads in area streams.

However, it should be noted that during low flow conditions, the wastewater effluent in a stream may represent water that helps to augment and maintain the minimum stream flows. Tail water is the term used to describe that water returned to the stream after application to irrigated cropland. Tail water carries nutrients, sediments, salts, and other pollutants from the farmland. This return flow can have a negative impact on water quality, and by implementing conservation measures which reduce tail water losses, the nutrient and sediment loading can be reduced. Once again, however, this return flow tends to be introduced into the receiving stream during normally dry periods so it may have a net beneficial effect in terms of maintaining minimum stream flow conditions. Furthermore, the loss of the return flows could be offset by a reduction in irrigation diversions resulting in no net affect on the stream flow.

### 4.3.2.2 Alternative 3A

For surface water resources, potential direct impacts from the proposed project generally would include flow and water quality effects on part of lower Trinity River, a portion of Cedar Bayou, and Lake Houston and its floodplain, modifications of existing runoff and sediment yield conditions within or adjacent to the proposed project area, effect on surface water features such as intermittent and ephermeral streams, and ponds, and effects to surface water quality in the project area and vicinity. Indirect impacts potentially would include the effects of river crossings on aquatic habitat, on other ecological or scenic values, on wetland hydrology, or on existing road infrastructure. The proposed IBT could potentially contribute to existing cumulative effects on surface water quantity and quality in the region.

Lake Houston is an in-channel impoundment (USGS 2000) and the lake bottom includes deep areas along the original river channel and shallower areas on the original banks' inundated parts. The geometry of Lake Houston in the northern part of the lake is complex, because three inlets converge (including Luce Bayou). Elevation and depth values were assigned to the model cells in the Lake Houston based on bathymetric data collected by the TWDB (TWDB 2003) and a tool for visualizing the water circulation patterns in Lake Houston was developed. Water velocity vectors in the lake's top and bottom layers were developed for specific model conditions. The visualizations allow the qualitative comparison of the model results with external stimuli such as wind speed, inflow and diversion rates. Historical water movement patterns for 2000, 2004 and 2008 were estimated using the EFDC model. The hydrodynamic model was developed to evaluate:

- Water movement related to the LBITP full diversion from the Trinity River
- Water movement related to differing water levels dictated by changes in Lake Houston operations, i.e., drops in water surface elevation of 0 feet (45.0 feet MSL), 2, and 5 feet (worst-case scenario)
- Water surface elevation impacts by historical inflow patterns (i.e., low-flow, high-flow and average-flow conditions)

The WASP model was used under various drawdown scenarios to simulate water quality in Lake Houston resulting from LBITP. The eutrophication module within WASP was used to simulate nutrient fate and transport. The same model grid developed for the EFDC model was used for WASP to allow flows estimated by EFDC to be used on WASP model input. Various water quality scenarios were defined by the Espey study to evaluate impacts on eutrophication and nutrient concentrations with LBITP and without LBITP, and various Lake Houston drawdown scenarios (0 feet, 2 feet, and 5 feet). The model results indicate most water quality parameters would not change appreciably after implementing the LBITP, except for dissolved oxygen and chlorophyll-a. However it was found that the LBITP would be beneficial to Lake Houston's water quality by increasing the dissolved oxygen rate and reducing hypoxic events and algal blooms. Among the various water quality parameters investigated, dissolved oxygen showed the largest variability as it decreased with increased drawdown to the greatest degree. Based on the study conducted, drawing down the Lake Houston water elevation deteriorates the water quality, because nutrient loads and benthic effects (such as sediment oxygen demand, benthic ammonia flux, and benthic phosphate flux) are exerted on a decreased water volume. Generally, the model scenario with the full LBITP diversion and no Lake Houston elevation change (0 feet drawdown) resulted in the best overall water quality for Lake Houston due to the good water quality from the Trinity River.

A study completed by the USGS to evaluate LBITP's effect on Lake Houston's water quality indicated no significant changes in water quality would occur. Results are discussed below.

- The proposed LBITP would not have an effect on salinity levels in the lower Trinity River or Lake Houston, since the project is not located in a tidally influenced area. Downstream from the proposed lower Trinity River diversion point and CRPS is a saltwater barrier (Wallisville Salt Water Barrier), which prevents saltwater intrusion from occurring in the Trinity River during low flow conditions.
- Water chemistry would not be impacted during LBITP's construction. The water transferred from the Trinity River to Lake Houston could locally result in an insignificant change to Lake Houston's water chemistry. No water chemistry change would occur in the Trinity River. The USGS assessed LBITP's effect on the Lake Houston's water quality, and determined that ammonia nitrogen would not be affected, and phosphorus and nitrite plus nitrate nitrogen may decrease slightly.
- Dissolved oxygen levels in Lake Houston would not change significantly (+1 part per million) due to transferring water from the Trinity River to Lake Houston (Espey 2010). Dissolved oxygen levels in the Trinity River would not be impacted by LBITP's construction or operation.
- Based on predictive models conducted for LBITP, there should be no change in water chemistry with respect to potential eutrophication or nutrient loading (Espey 2010). The Trinity River and San Jacinto River basins (Lake Houston) exhibit similar characteristics. No additional nutrient sources or impacts would be expected due to LBITP, although a decrease in nutrient loading to Gillen Bayou may occur as cattle operations cease in the area proposed for compensatory mitigation.
- Short-term increases in water turbidity and associated decreases in water clarity would be expected during LBITP construction activities. During operation, some increases in turbidity could occur in the pump station's immediate vicinity (Trinity River) and outfall (Luce Bayou). The turbidity would be localized, and suspended sediment would settle from the water column with time.

The LBITP is the interbasin transfer of water from one watershed to another. Interbasin transfers such as this allow an increased opportunity for invasive species migration from the source to receiving waters. Additionally, the transfer will potentially reduce flow in the Trinity River below Dayton, because the Lake Livingston water rights are not fully utilized today. The effects of this reduced flow in the lower Trinity River would be mitigated by the existence of the Wallisville Saltwater Barrier at the mouth of the river, which maintains a minimum river level for navigation and prevents the migration of brackish water upstream.

Construction for a sedimentation basin is proposed as part of LBITP. The basin would be approximately three miles from the CRPS at the discharge end of the proposed Alternative 3A pipeline, immediately upstream of the conveyance canal. The sedimentation basin would remove sediment pumped through the lower Trinity River intake and conveyed through the proposed LBITP pipeline. The water flow rate into the sedimentation basin would be designed so the majority of the conveyed sediment would settle to the basin's bottom and would not be discharged into LBITP's conveyance canal. The sediment contained within the basin would be periodically removed and stored onsite prior to final disposition.

In 2000, in conjunction with Houston, the USGS investigated the effects from transferring Trinity River water into Lake Houston, either to augment East Fork stream flow or to replace West Fork stream flow. Alternative 3A does not appear to be detrimental to water temperature, ammonia nitrogen, or dissolved oxygen regardless of the water transfer scenario modeled or evaluated. Phosphorus and nitrite plus nitrate nitrogen showed fairly large changes if Trinity River water was transferred into Lake Houston to replace West Fork stream flow, and minimal or no change if Trinity River water was transferred to augment East Fork stream flow (USGS 2000). Algal biomass showed large decreases if Trinity River water was transferred into Lake Houston to augment East Fork stream flow, and large increases if Trinity River water was transferred to replace West Fork stream flow. Regardless of the water-transfer scenario modeled, the model results indicated light is the limiting factor for algal biomass growth (*Estimated Effects on Water Quality of Lake Houston from Interbasin Transfer of Water from the Trinity River, Texas,* USGS Water Resource Investigations Report 00-4082 [2000] **Appendix J**).

Espey Consultants, Inc. performed an in-depth evaluation on Alternative 3A's impact on water quality in Lake Houston based on hydrodynamic and water quality modeling (reference: *LBITP Water Quality Assessment and Hydrodynamic Study* 2009; **Appendix K**). The Water Quality Analysis Simulation Program (WASP) model helps predict water quality responses to natural conditions. The WASP model is a dynamic compartment-modeling program for aquatic systems that was linked with the Environmental Fluid Dynamics Code (EFDC) hydrodynamic model to help understand Alternative 3A's effects on water quality and the aquatic system given historical flow data, water depths and water mixing.

The lower Trinity River segment in the vicinity of the LBITP is not used for commercial navigation and, therefore, no impacts to regional commercial shipping would occur. See **Section 4.7** relative to potential impacts to recreational boating and canoeing. As with other elements constructed within the lower Trinity River, short-term temporary increases in suspended sediment concentrations, turbidity, and sediment deposition would occur from project-related disturbance. Short-term temporary increases in suspended sediment concentrations, turbidity, and sediment deposition would be minimized by implementation of erosion control measures. During the inactive periods, high flows would subject stockpiled materials to erosion. Flow paths between material stockpiles, construction area, and the haul road would promote additional erosion, turbidity, and sedimentation between the embankments and into the river during overbank flows. These flow and water quality impacts would be short-term in nature. Because of the potential for these impacts from excavation, stockpiling, and equipment tracking during wet periods, monitoring and mitigation may need to be considered. Construction effects and the long-term presence of the LBITP structures present in the lower Trinity River may induce channel migration although additional studies and modeling would be performed during final design to develop appropriate long-term mitigation for channel migration.

Upstream or downstream effects could occur; old channel scars occur in both directions. A relatively straight reach of the river is downstream and with adequate foundations, the proposed bridge and embankment would help anchor the channel. These factors likely would minimize downstream bank shifting and channel migration. The river is strongly meandering upstream of the crossing. Flood flows through Mud Creek and circulation patterns near Capers Ridge of the lower Trinity River during flooding may encourage additional bar and bank shifts in meanders and effects on opposite and adjoining properties owned by the USFWS (Trinity River NWR parcels near both the proposed CRPS and the existing TRPS). Additional sediment transport, turbidity, and deposition could result and these effects could vary widely in their intensity and timing and hence potential effects.

The lower Trinity River is dominantly a sand-bed channel (Baird 2010). Based on general sand sizes and flocculation of smaller particles in the flow, suspended sediments from construction during low flows likely would settle out within a mile or so downstream of the proposed channel crossing. For example, with a flow depth of approximately 4.5 feet and a mean downstream velocity of approximately 1.2 to 1.5 f/s, a small sand particle will settle out of reasonably calm flow in approximately 100 feet or less. Re-suspension could increase that distance, but it gives a general idea of a potential downstream impact area for sands. Under the same conditions, dispersion and settling of clay aggregates from the water column typically would occur over a much greater river distance. Depending on water chemistry and a concentration criterion, silts and clays in that flow may require 0.5 mile or more to settle out to the criterion or to a background concentration. Changes in flows, turbulence, and re-suspension would modify those settling distances as well as background concentrations. Nonetheless, increases in suspended sediment concentrations, turbidity, and sediment deposition would occur from project disturbance in and adjacent to the river, generally on the order of the distances mentioned here. These water quality changes would be short-term in nature. Because of the potential for channel mitigation, sedimentation, and turbidity impacts to a waterbody that is a candidate “Ecologically Significant River Segment”, additional mitigation is being considered as discussed in **Chapter 6** (Baird 2010 and Baird 2012).

#### 4.3.2.3 Alternative 4

As described in **Chapter 2**, **Section 2.7**, these actions would result in short-term to long-term impacts to surface water resources in the project area. Alternative 4 is estimated to impact 66-wetland-acres and a little over 4,000 linear-feet of waters of the U.S., including wetlands. Alternative 4 would also realize a low number of wetland impacts and would traverse through mostly agricultural land uses. Because of these features, it will also be evaluated in more detail in this DEIS.

Varying lengths for intermittent and perennial streams and stream segments would be located within the 300-foot wide corridor proposed for Alternative 4. Stream lengths are estimated according to linear-feet of stream located within the Alternative 4 ROW. For alternatives designed as subsurface pipeline for most of the conveyance distance or for a limited distance, the potential exists to avoid most stream segments by tunneling beneath the stream. However, virtually all woody vegetation and trees within any of the pipeline ROW would be cleared and permanently maintained as grassed areas.

Alternative 4 crosses through part of the Cedar Bayou watershed. About half of the watershed is in Harris County and the other half in Liberty and Chambers counties. Cedar Bayou is a southward flowing stream originating in Liberty County and enters Galveston Bay approximately 60 miles from its headwaters. The watershed encompasses approximately 202 square miles, and Cedar Bayou is the primary surface water feature. About 128 miles of open streams exist within the Cedar Bayou watershed, inclusive of the bayou itself and its tributaries.

Constructing and operating either improved canal conveyances or pipelines effect the watershed including altered drainage patterns and introducing other pollutants due to pipeline ROW or canal O&M. Mitigating these would require detailed management plans and consistent plan enforcement. Generally, any conveyance alternative traversing the watershed would have the potential to adversely affect the watershed's physical, chemical, and biological health. Alternatives using the existing canal system could have a lesser impact on the watershed. However, necessary improvements to the system as described earlier and the likelihood new canal alignments would be required to avoid wetlands reduces the feasibility to extensively use the existing canal system without major changes.

#### 4.3.2.4 Alternative 6

As described in **Chapter 2,** the proposed LBITP would result in short-term to long-term impacts to surface water resources in the project area. Varying lengths for intermittent and perennial streams and stream segments would be located within the 300-foot-wide corridor proposed for Alternative 6. Stream lengths are estimated according to linear-feet of stream located within the Alternative 6 ROW. For alternatives designed as subsurface pipeline for most of the conveyance distance or for a limited distance, the potential exists to avoid most stream segments by tunneling beneath the stream. However, virtually all woody vegetation and trees within any of the pipeline ROW would be cleared and permanently maintained as grassed areas.

One area to be traversed by Alternative 6 is the Cedar Bayou watershed. About half of the watershed is in Harris County and the other half in Liberty and Chambers counties. Cedar Bayou is a southward flowing stream originating in Liberty County and enters Galveston Bay approximately 60 miles from its headwaters. The watershed encompasses approximately 202 square miles, and Cedar Bayou is the primary surface water feature. About 128 miles of open streams exist within the Cedar Bayou watershed, inclusive of the bayou itself and its tributaries.

Constructing and operating either improved canal conveyances or pipelines effect the watershed, including altered drainage patterns and introducing other pollutants due to pipeline ROW or canal O&M. Mitigating these would require detailed management plans and consistent plan enforcement. Generally, any conveyance alternative traversing the watershed would have the potential to adversely affect the watershed's physical, chemical, and biological health. Alternatives using the existing canal system could have a lesser impact on the watershed. However, necessary improvements to the system as described earlier and the likelihood new canal alignments would be required to avoid wetlands reduces the feasibility to extensively use the existing canal system without major changes.

### 4.3.3 Water Resources Development

Upper basin return flows are an important consideration in this study due to their inclusion in the base model and, in particular, the substantial contributions made by Region C return flows to Region H in the Trinity Basin model. Water imports into the upper Trinity River Basin account for additional return flows which may potentially be an important source for lower basin water rights and B&E inflows. This is made even more important due to the Trinity being a source basin for several major IBTs to the San Jacinto supplying the major demand centers in Region H. The importance of return flows to the WMS models presented in this study is highlighted by comparing the C and F model results. For every month of the full simulation period, adding return flows in the C model resulted in increased B&E flow over the F model, with a 27,897 acre-foot minimum monthly increase and a 80,878 acre-foot median increase.

#### 4.3.3.1 No Action

The impacts to future water supply resulting from the method used to address B&E target flow shortages can be demonstrated as a function of future firm yield and future reservoir storage. Releasing stored water from Lake Houston and Lake Livingston will result in reduced water supplies available for diversion for both reservoirs and potential upstream supply reductions. Supply impacts can be quantified as a reduction in future firm yield and/or a reduction in future reservoir storage.

Firm yields were calculated for the E model and revised models for key rights, including supplies identified in the 2006 RWP and as potentially impacted WMS. Results from the revised models were compared to the E model to determine any change in minimum annual diversion. The results, shown in **Table 4-5**, demonstrate that, in spite of the significant effects on reservoir levels, the altered reservoir operations used to meet FTA goals do not alter Trinity or San Jacinto Basin's firm yields, because the reservoirs do not empty at any time and monthly diversions continue to be met from a combination of reservoir inflow and stored water.

These results, indicating no impact to firm yield supply due to reservoir releases, primarily come from including expected return flows in the E model. Importing water coupled with including expected return flows in the E model creates significant water volumes in the lower Trinity and San Jacinto basins made available for firm yield diversions and B&E flow releases. These return flows; however, are not currently permitted for use in the lower basins. Without including these return flows, the impact to future firm yield for the supplies would be significantly more pronounced.

**Table 4-5:**
**Minimum Annual Diversions for Max H and Min Q-Sal Reservoir Operation**

| | | | **Model Minimum Annual Diversion** (ac-ft) | | |
|---|---|---|---|---|---|
| **Basin** | **Description** | **Permit** (ac-ft) | **E** | **Revised Max H** | **Revised Min Q-Sal** |
| San Jacinto | Lake Houston | 168,000 | 168,000 | 168,000 | 168,000 |
| San Jacinto | Lake Conroe | 100,000 | 82,266 | 82,266 | 82,266 |
| Trinity | Houston Livingston | 940,800 | 940,800 | 940,800 | 940,800 |
| Trinity | *SJRA/Devers ROR | 58,500 | 58,285 | 58,285 | 58,285 |
| Trinity | *Houston/Dayton | 38,000 | 34,084 | 34,084 | 34,084 |
| Trinity | CLCND - Lake Anahuac | 39,613 | 9,317 | 9,317 | 9,317 |
| Trinity | *CLCND Fixed Right – CWA | 73,334 | 73,334 | 73,334 | 73,334 |
| Trinity | *SJRA - CLCND Fixed Right - CWA | 30,000 | 30,000 | 30,000 | 30,000 |
| Trinity | Livingston – TRA | 403,200 | 403,200 | 403,200 | 403,200 |

**Established through fixed right agreements.

#### 4.3.3.2 Alternative 3A, Alternative 4, and Alternative 6

Upper basin return flows are an important consideration due to their inclusion in the base model and, in particular, the substantial contributions made by Region C return flows to Region H in the Trinity Basin model. Water imports into the upper Trinity River Basin account for additional return flows which may potentially be an important source for lower basin water rights and B&E inflows. This is made even more important due to the Trinity being a source basin for several major IBTs to the San Jacinto River basin that provides water to Houston.

### 4.3.4 Water Supply and Management

For this analysis related to the implementation of the LBITP (all action alternatives), the TCEQ Water Availability Model was updated to include the water management strategies recommended by the Region C and Region H planning process. The tributaries to Galveston Bay were then modeled under four scenarios to compare the results with and without the recommended strategies. The scenarios used were Run 8 "Current Conditions" (current levels of water diversions and return flows), Run 1 (full use of water rights with current percentage of return flows), Run 3 (full use of water rights with no return flows) and a future condition (full use of water rights, new strategies in place, and full return flows except for recommended reuse strategies). The first three models used the year 2000 reservoir sedimentation conditions to represent the 2010 condition, and the fourth used the 2060 condition. The future sedimentation condition benefits downstream projects, because upper basin projects have less capacity to store available flows. In this case, Lakes Houston and Livingston may be considered downstream projects.

The results of these simulations are summarized in **Table 4-6**. Reservoir elevations, capacities and surface areas are shown in **Figure 4-7, Figure 4-8** and in **Figure 4-9** as a reference. Percentile values indicate the percentage of time the result value is less than or equal to the subject value. Therefore, the maximum value is the full lake elevation, the median value is the lake level in 50 percent of the monthly outputs, and the minimum value is the lowest monthly elevation in the simulation. Because the yield of these water supply reservoirs is based upon full use of the stored water during the drought of record, the Run 3 minimum elevation is, by definition, the lake bottom elevation. Note that this value is greater in the 2060 conditions simulation due to the projected accumulation of sediments on the reservoir floor. Each simulation run used the same 57-year inflow data set, which includes the drought of record period.

**Table 4-6:**
**Lake Level Percentile Summaries**

Lake Conroe Water Surface Elevations

| | Current Conditions | Yr 2010 Run 1 | Yr 2010 Run 3 | Yr 2060 w/ Strategies |
|---|---|---|---|---|
| Maximum | 201.0 | 201.0 | 201.0 | 201.0 |
| 90th | 201.0 | 201.0 | 201.0 | 201.0 |
| 75th | 201.0 | 200.5 | 200.5 | 200.5 |
| Median | 200.5 | 198.4 | 198.2 | 198.5 |
| 25th | 198.6 | 193.6 | 193.0 | 194.2 |
| 10th | 195.3 | 184.2 | 183.1 | 185.9 |
| Minimum* | 187.8 | 145.0* | 145.0* | 152.0* |

*estimated

Lake Houston Water Surface Elevations

| | Current Conditions | Yr 2010 Run 1 | Yr 2010 Run 3 | Yr 2060 w/ Strategies |
|---|---|---|---|---|
| Maximum | 44.0 | 44.0 | 44.0 | 44.0 |
| 90th | 44.0 | 44.0 | 44.0 | 44.0 |
| 75th | 44.0 | 44.0 | 44.0 | 44.0 |
| Median | 44.0 | 44.0 | 44.0 | 44.0 |
| 25th | 43.3 | 43.3 | 42.8 | 44.0 |
| 10th | 42.0 | 42.0 | 40.4 | 43.8 |
| Minimum | 32.8 | 32.8 | 9.0* | 40.3 |

*estimated, surface elevation shown is lake bottom

Lake Livingston Water Surface Elevations

| | Current Conditions | Yr 2010 Run 1 | Yr 2010 Run 3 | Yr 2060 w/ Strategies |
|---|---|---|---|---|
| Maximum | 131.0 | 131.0 | 131.0 | 131.0 |
| 90th | 131.0 | 131.0 | 131.0 | 131.0 |
| 75th | 131.0 | 131.0 | 131.0 | 131.0 |
| Median | 131.0 | 131.0 | 129.8 | 131.0 |
| 25th | 130.5 | 130.4 | 124.3 | 129.5 |
| 10th | 129.0 | 128.0 | 116.5 | 127.1 |
| Minimum | 125.5 | 114.0 | 60.0* | 120.7 |

*estimated, surface elevation shown is lake bottom

As can be seen from **Table 4-7**, under current conditions Lake Conroe would have a 13-foot elevation variation range during the historical period, Lake Houston an 11-foot range and Lake Livingston a 5-foot range. In all cases, the lakes are essentially full more than 50 percent of the time. To compare the runs with and without management strategies, it is best to compare Run 1 with the Recommended Strategies simulation, because both models use expected return flows.

**Figure 4-7:**
**Lake Conroe Surface Area and Capacity (2060 Conditions)**

| Surface Elevation | Surface Area | Storage Volume | Fill |
|---|---|---|---|
| Feet (msl) | Acres | Acre-Feet | Percent |
| 201 | 19,360 | 377,560 | 100 |
| 195.5 | 15,600 | 283,170 | 75 |
| 188.7 | 12,190 | 188,780 | 50 |
| 179.5 | 8,500 | 94,390 | 25 |
| 152 | | | Bottom |

**Figure 4-8**
**Lake Houston Surface Area and Capacity (2060 Conditions)**

| Surface Elevation | Surface Area | Storage Volume | Fill |
|---|---|---|---|
| Feet (msl) | Acres | Acre-Feet | Percent |
| 44 | 11,850 | 106,410 | 100 |
| 41.5 | 9,250 | 79,810 | 75 |
| 38.0 | 7,780 | 53,210 | 50 |
| 33.4 | 5,700 | 26,600 | 25 |
| 20 | | | Bottom |

**Figure 4-9**
**Lake Livingston Surface Area and Capacity (2060 Conditions)**

| Surface Elevation | Surface Area | Storage Volume | Fill |
|---|---|---|---|
| Feet (msl) | Acres | Acre-Feet | Percent |
| 131 | 82,920 | 1,717,080 | 100 |
| 125.4 | 70,600 | 1,287,810 | 75 |
| 118.6 | 56,920 | 858,540 | 50 |
| 109.8 | 39,510 | 429,270 | 25 |
| 63 | | | Bottom |

For Lake Conroe, full use of water rights reduces the frequency of the lake being full from 50 percent to 25 percent of the time in every simulation. The lake level falls below the current conditions minimum elevation between 10 and 25 percent of the time. The transfer of water to Lake Houston via Luce Bayou slightly increases the levels in Lake Conroe, but otherwise the two models are about the same.

For Lake Houston, the full use of water rights does not significantly change the lake level frequencies. This is mainly due to the fact that Lake Houston is senior in priority date to Lake Conroe, and therefore the model always stores available flows in Lake Houston first, and then makes the remainder available to Lake Conroe. In actual operation, a better balance is maintained between the two, but Lake Conroe will always decline faster than Lake Houston because it is supplied from a smaller watershed. Of note in the future condition simulation is that the import of water through Lake Houston via the Luce Bayou transfer increased the frequency of the lake being full from 50 percent to 90 percent of the time.

Finally, the Lake Livingston results show how dependent the reservoir is upon return flows from upstream (Run 3 condition). Under the recommended strategies run, the results are very close to the current conditions simulation. This is because increased use in the upper Trinity Basin is off-set by increased import of out-of-basin supplies. Region H indirectly benefits from the growth of the Dallas-Fort Worth Metroplex. In the current round of planning, Region C is increasing the amount of recommended reuse, although it is not expected they will reach the full-reuse condition modeled in Run 3.

The drought of record lasted six years, and subsequent droughts have exceeded two years in duration. Based on simulations and modeling, when significant declines in lake levels occur, they will not be instantaneous events, but will be a subset of the overall drought period. Generally speaking, a month with low lake levels will impact a land owner's ability to use a dock. A year with low lake levels may impact his property rental or resale value. Similar inferences may be made as to the impacts on lake area communities and businesses.

Reduced lake levels will also impact water quality. During extreme low flow periods, reduced residence time in the reservoir will lessen the beneficial affects of sediment settling. Because the climate in this area is mild, the seasonal turn-over in lakes occurs less frequently than in colder climates. When reservoirs are drawn down, the denser lower layer of water will be withdrawn, which may increase the level of treatment required for use.

### 4.3.5 Environmental Flows

In 2007, Senate Bill 3 took effect, beginning the environmental flows allocation process for new water rights permits in Texas. The water management strategy described by regional water planning efforts as the LBITP is authorized by existing Houston water-rights permits which are not subject to future environmental flow allocations.

The 2009 *Environmental Flows Study* was supplemented by the Region H RWP to evaluate environmental flows in the year 2060, and another study was conducted to determine the impacts of management strategies in the decades of 2010, 2020, 2030, 2040, 2050 and 2060. This study over the entire planning horizon took into account impacts from upstream return flows from and reuse within Region C to determine overall variation in inflows to Galveston Bay. In general, the study demonstrated near-term reductions in return flows from the upper Trinity River Basin were mitigated over time due to increased demands in the upper basin. These increased flows also counteracted increased water supply use by Region H.

Based on the SB 1 analyses conducted, the LBITP was in compliance with Galveston Bay Freshwater Inflows Group (GBFIG) target inflows using State Methodology for determining freshwater inflow needs. Under SB 3, as of April 20, 2011 (effective May 15, 2011), the TCEQ adopted environmental flow standards for the Trinity and San Jacinto Rivers and their associated tributaries, and Galveston Bay including Trinity, East and West Bays (30 TAC 298 Subchapter B), as required under SB 3. These environmental flows standards identify target environmental flow goals that were developed to meet a sound ecological environment while considering competing water needs such as the present and future water requirements presented by the Region H RWP (including the proposed LBITP) and adopted as part of the State Water Plan (2011).

### 4.3.5.1 No Action

During normal flow conditions in the Trinity River, sufficient flow is present to meet all downstream water rights. Under low flow conditions, Lake Livingston reservoir operators carefully track raw water withdrawals and release only as much water from the reservoir as is needed to meet all downstream water rights. Over the past 20 years, flows in the Trinity River have generally been maintained above 757 cfs or the 1 percent calculated flow-through of releases from Lake Livingston.

### 4.3.5.2 Alternative 3A

After the proposed project has been constructed and is operational, the TRA would release additional water during otherwise low flow periods to meet LBITP's permitted water demand. Future low flow rates were determined through a modeling exercise conducted for the LBITP. Trinity River's minimum water surface elevation (WSE) is expected to be approximately 16.9 feet MSL. This elevation is associated with an approximate 1,000 cfs minimum flow rate at Capers Ridge. The anticipated minimum flow rate maintained by releases from Lake Livingston after Alternative 3A has been constructed is anticipated to be higher than flow rates during in the last 20 years in the Capers Ridge vicinity, resulting in a potential positive, although variable, benefit to the flow regime.

The *Environmental Flows Study* (2009) was developed to analyze the effects of the LBITP on B&E flows of the lower Trinity River and Galveston Bay. Based on the analyses conducted, the LBITP was in compliance with Galveston Bay Freshwater Inflows Group (GBFIG) target inflows using State Methodology for determining freshwater inflow needs. Based on the SB 1 analyses conducted, the LBITP was in compliance with GBFIG target inflows using State Methodology for determining freshwater inflow needs. Under SB 3, as of April 20, 2011 (effective May 15, 2011), the TCEQ adopted environmental flow standards for the Trinity and San Jacinto Rivers and their associated tributaries, and Galveston Bay including Trinity, East and West Bays (30 TAC 298 Subchapter B), as required. These environmental flows standards identify target environmental flow goals that were developed to meet a sound ecological environment while considering competing water needs such as the present and future water requirements presented by the Region H RWP (including the proposed LBITP) and adopted as part of the State Water Plan (Region H RWP 2011).

Based on the dissertation, *Environmentally-related Water Trading, Transfers and Environmental Flows: Welfare, Water Demand and Flows* used the TEXRIVERSIM model (and other analyses) water use, flows and freshwater inflows for the San Jacinto River watershed (i.e., the IBT receiving basin) all increased due to the proposed LBITP water transfer and diversion. In addition, for the San Jacinto River basin, the relationship between freshwater diversion was, on a relative basis, strongly positive (Han 2008). The freshwater inflow recommendations to meet B&E requirements could also be met on average for the Trinity River basin and Galveston Bay based on the study conducted.

The B&E flow pattern to the Galveston Bay system from the Trinity River results from the combined effects of Region H water management strategies including upstream implementation of Region C conservation strategies (reuse and return flows). Evaluation of Region C return flows and Trinity Bay inflows indicate upstream reuse will have an effect on Galveston Bay inflows. Based on modeling studies, the net effect on B&E flows into Galveston Bay from approved Region H water management strategies after 2010, including Alternative 3A, meet the Galveston Bay Freshwater Inflows Group (GBFIG) identified environmental flow targets, although there is anticipated to be year-to-year variability. See **Appendix A** for a copy of the *Environmental Flows Study* issued in 2009 which provides an analysis of the environmental flow effects on Region H's proposed water management strategies including the LBITP.

Due to the recent adoption under the Texas SB 3 program for Galveston Bay system's freshwater inflow standards, the decision-making process for future water rights applications would be guided by a new set of freshwater inflow criteria. Although these new criteria do not directly apply to LBITP, since its water rights are already in place, the impact from implementing LBITP was evaluated as it relates to the attainment frequency for these new seasonal and annual target flow criteria. In particular, the attainment frequency for these new criteria was modeled using the same models described previously for the base condition D both with and without LBITP as described in the subsection above.

**Table 4-8** and **Table 4-9** show the FTA both with and without LBITP for the three different target frequencies of four seasonal flow volumes, which are identified under the SB 3 program. Under both alternatives, the Trinity River diversions from LBITP and TRPS result in reduced freshwater inflows into Trinity Bay and a corresponding increase in flow volumes into San Jacinto Bay; therefore, only the reductions in FTA for Trinity Bay are shown below.

**Table 4-8:**
**Target Freshwater Inflows for Trinity Bay with LBITP**

| | Target (Ac-Ft) | | Percent Period Meeting Target | | | |
|---|---|---|---|---|---|---|
| **Season** | **Flow** | **Frequency (Percent)** | **2010** | **2020** | **2040** | **2060** |
| Winter | 500,000 | 40 | 75 | 73 | 73 | 73 |
| Spring | 1,300,000 | 40 | 63 | 63 | 63 | 63 |
| Summer | 245,000 | 40 | 58 | 56 | 56 | 56 |
| Fall | 0 | 40 | 100 | 100 | 100 | 100 |
| **Annual** | **2,816,532** | **40** | **70** | **70** | **70** | **70** |
| Winter | 250,000 | 50 | 88 | 88 | 88 | 88 |
| Spring | 750,000 | 50 | 68 | 68 | 68 | 68 |
| Summer | 180,000 | 50 | 65 | 63 | 60 | 60 |
| Fall | 0 | 50 | 100 | 100 | 100 | 100 |
| **Annual** | **2,245,644** | **50** | **75** | **75** | **75** | **75** |
| Winter | 160,000 | 60 | 89 | 88 | 88 | 88 |
| Spring | 500,000 | 60 | 82 | 79 | 75 | 75 |
| Summer | 75,000 | 60 | 75 | 75 | 74 | 74 |
| Fall | 0 | 60 | 100 | 100 | 100 | 100 |
| **Annual** | **1,357,133** | **60** | **81** | **81** | **81** | **81** |

**Table 4-9:**
**Target Freshwater Inflows for Trinity Bay Without LBITP**

| | Target (Ac-Ft) | | Percent Period Meeting Regime Drought Inflow | | | |
|---|---|---|---|---|---|---|
| **Season** | **Flow** | **Frequency (Percent)** | **2010** | **2020** | **2040** | **2060** |
| Winter | 500,000 | 40 | 75 | 75 | 73 | 75 |
| Spring | 1,300,000 | 40 | 63 | 63 | 63 | 63 |
| Summer | 245,000 | 40 | 58 | 58 | 56 | 58 |
| Fall | 0 | 0 | 100 | 100 | 100 | 100 |
| **Annual** | **2,816,532** | **40** | **70** | **70** | **70** | **70** |

| Season | Target (Ac-Ft) Flow | Frequency (Percent) | Percent Period Meeting Regime Drought Inflow 2010 | 2020 | 2040 | 2060 |
|---|---|---|---|---|---|---|
| Winter | 250,000 | 50 | 88 | 88 | 88 | 88 |
| Spring | 750,000 | 50 | 68 | 68 | 68 | 68 |
| Summer | 180,000 | 50 | 65 | 65 | 65 | 65 |
| Fall | 0 | 0 | 100 | 100 | 100 | 100 |
| **Annual** | **2,245,644** | **50** | **75** | **75** | **75** | **75** |
| Winter | 160,000 | 60 | 89 | 89 | 89 | 89 |
| Spring | 500,000 | 60 | 82 | 82 | 81 | 81 |
| Summer | 75,000 | 60 | 75 | 75 | 75 | 75 |
| Fall | 0 | 0 | 100 | 100 | 100 | 100 |
| **Annual** | **1,357,133** | **60** | **81** | **81** | **81** | **81** |

As shown in the two tables, even with the substantial reductions in flow caused by these future diversions, the targeted attainment frequencies for all seasonal and annual volumes are achieved on a greater percentage rate than required for the TCEQ adopted standards. This is true for all decades modeled and for all seasons, whether all diversions are occurring at the TRPS (without LBITP) or at CRPS (with Alternative 3A). The lowest FTA is for the summer season where a 56-58 percent FTA is achieved for the 40 percent frequency goal, a total of 16 to 18 percent above the FTA. The closest FTA to any goal is for the summer 60 percent target where the FTA is 74 percent in some decades, representing only 14 percent greater than desired.

The principal conclusion from this analysis is the *high level of return flows remaining in the Trinity River basin and the naturally occurring high flow events are adequate to achieve the TCEQ freshwater inflow targets for Trinity Bay, even with substantial future diversions required to serve Houston and its industrial and regional customer's water supply requirements.* This study was intended to evaluate the impacts from individual management strategies on environmental flows including B&E inflows and instream flows in channels. An evaluation of impacts to existing and future water supplies was also performed for two scenarios aimed at increasing the frequency for attaining B&E inflow targets. The following observations were made through the course of the study:

In general, including strategies upstream from and within Region H generally leads to a net increase in B&E inflows due to importing new water to the basin. B&E flows generally transition from originating in the Trinity River Basin to the San Jacinto River Basin as time passes, and additional water is diverted to meet water demands of the San Jacinto River basin. Removing return flows from Region C resulted in a 20 percent reduction in B&E discharges from the Trinity River, which represents a substantial impact to the total volume of B&E flows. Reductions in the firm yield for six of seven key water rights were also caused by eliminating upstream return flows.

### 4.3.5.3 Instream Flows

The predominant source of change to instream flows to rivers would be related to increases in flow due to new water sources such as IBTs and groundwater recharge. The LBITP is intended to receive water at a point (Capers Ridge) above the existing TRPS; water supply from Capers Ridge would be delivered to Lake Houston for treatment at the Northeast Water Purification Plant (NEWPP). The LBITP would not replace current demand for water from the EWPP or the SEWPP that receive water from the existing TRPS. Over time, the demand for water at both the proposed CRPS and the TRPS would increase due to projected population growth. When the LBITP is added as a diversion along the Trinity River, additional reservoir releases would occur to provide available flows in excess of TRPS demand at the Capers Ridge diversion point in accordance with the water rights permit. Therefore, the presence of the LBITP reduces the magnitude of flows in excess of TRPS demand in the Trinity River. For the median flows, this reduction becomes more pronounced downstream.

AECOM investigated the potential effects of the LBITP on instream flows in the lower Trinity River. The results of that study showed that, at shorter timescales, the presence of the LBITP and withdrawals at the proposed CRPS, along with the projected increased demand at the existing TRPS, would enhance flows in the river during times of low river flows as releases are made from Lake Livingston. For this phenomena, the greatest effect would be in the river reach that extends from Lake Livingston to the Capers Ridge diversion point. At the same time, LBITP diversion of Trinity River may result in a dampening of peak flows, primarily downstream of Capers Ridge. In addition, there may be an increased baseflow in the Trinity River as water is conveyed from Lake Livingston to the CRPS and the existing TRPS. This effect may be naturally mitigated through increased downstream tributary contributions to the lower Trinity River. Reductions in annual median flow increase with time as diversions increase, with these effects being most pronounced downstream of Capers Ridge (further downstream of the Romayor gauge). However, on an annualized basis, the apparent reduction in lower Trinity River instream flows is approximately seven percent (see **Appendix M**).

#### 4.3.5.4 Reduction and Mitigation of Potential Impacts

CWA operational and water quality goals for Lake Houston include minimizing change to the Lake Houston water level elevations and meeting the daily water demands at the NEWPP by carefully operating the LBITP (i.e., Alternative 3A, Alternative 4 or Alternative 6). To address these issues, the Region H Planning Group authorized a study to evaluate a variety of flow conditions for the year 2060, and examine the impacts from individual WMS. The Water Rights Analysis Package (WRAP) was executed for five baseline conditions, which did not include Region H strategies, plus 12 sets of strategy models that were intended to isolate the impacts from individual Region H WMS. Strategy models were developed from a base model representing Full Authorized Diversion conditions with expected return flows and no term permits. A study was also undertaken to assess methods for increasing the frequency at which B&E inflows targets were attained and assess the impacts such an approach would have on existing and future water supplies.

Alternative 3A is located in Region H of TWDB's designated areas for state water planning efforts. The environmental flow requirements developed by Texas for the downstream Trinity River, Trinity Bay, and Galveston Bay have been refined and ultimately adopted on a percentage basis by the GBFIG. Freshwater inflow sources to the bay are a combination of major and minor rivers and surface inflow from the surrounding watershed (i.e., storm water runoff) which goes directly into the bay. Freshwater inflows contributions into Galveston Bay include: 54 percent from the Trinity River, 28 percent from the San Jacinto River and 18 percent from the local watershed (runoff and creeks) (GBFIG 1995). The 2011 Initially Prepared Region H Water Plan incorporates as an Appendix the *Environmental Flows Study* issued in 2009. The *Environmental Flows Study* considered B&E flows for all the water management strategies described by the 2011 Initially Prepared Region H Water Plan with reference to B&E inflow targets recommended by the TWDB and the TPWD. These target inflows were examined primarily in terms of frequency target attainment (FTA). Three sets of targets designed for maintaining fisheries have been established, and are as follows.

- Max H – The monthly inflows sequence required for the maximum B&E fisheries harvest as recommended by TWDB/Texas Parks and Wildlife Department (TPWD)
- Min Q – The monthly inflows sequence that minimizes annual volume needed to maintain the B&E fisheries harvest as recommended by TWDB/TPWD
- Min Q-Sal – The monthly inflows sequence that maintains the B&E salinity constraint as recommended by TWDB/TPWD

Monthly values for all three annual targets for the Galveston Bay system are shown in **Table 4-10**. In general, Max H represents a target condition for ultimate production (i.e., to maximize harvest) while Min Q-Sal (minimum water quality represented by salinity) is a base condition that must be maintained on a more reliable basis to maintain aquatic systems.

**Table 4-10:**
**Monthly Galveston Bay Inflow Targets (acre-feet)**

| Month | Max H | Min Q | Min Q-Sal |
|---|---|---|---|
| 1 | 150,500 | 150,500 | 150,490 |
| 2 | 155,200 | 216,700 | 216,700 |
| 3 | 652,800 | 363,900 | 363,900 |
| 4 | 632,500 | 352,600 | 267,270 |
| 5 | 1,273,700 | 679,700 | 309,970 |
| 6 | 839,700 | 448,100 | 413,560 |
| 7 | 211,500 | 232,700 | 211,500 |
| 8 | 140,000 | 154,000 | 140,000 |
| 9 | 103,000 | 330,200 | 102,960 |
| 10 | 78,600 | 251,900 | 78,600 |
| 11 | 351,500 | 351,500 | 164,390 |
| 12 | 626,800 | 626,800 | 93,870 |
| **Total** | **5,215,800** | **4,158,600** | **2,513,210** |

Source: AECOM Team 2010

The modeling scenarios evaluated for this study included:

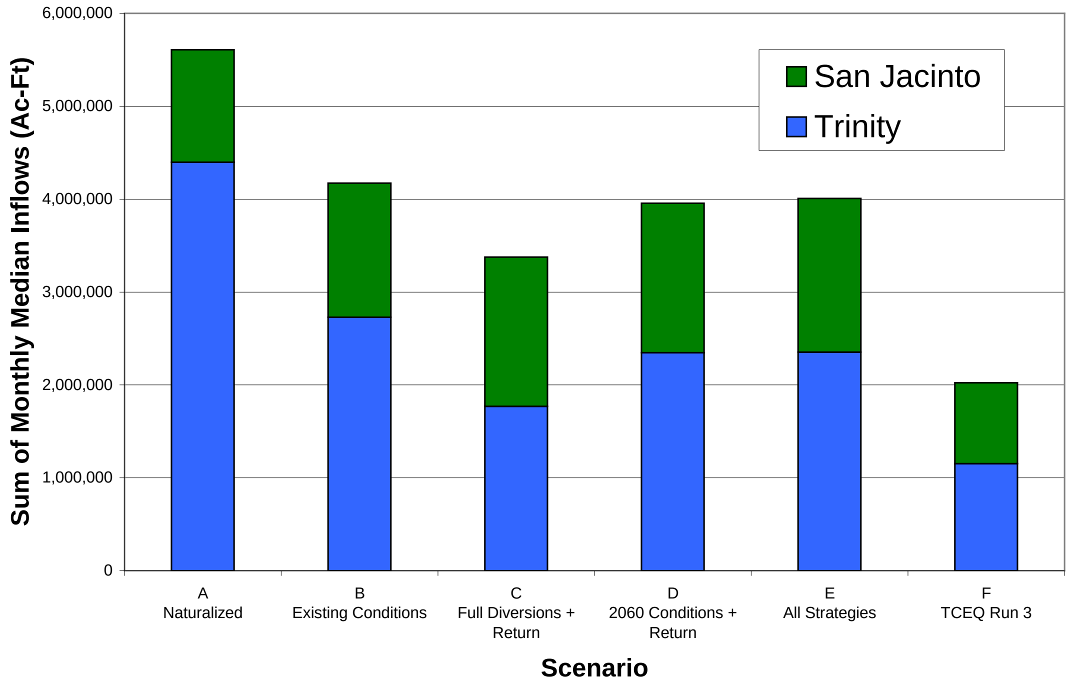
- Scenario A: Naturalized flow—or a flow simulation which would have occurred without the presence of man's influence in the basin.
- Scenario B: Existing diversions with full return flows.
- Scenario C: Full authorized diversions with full return flows.
- Scenario D: Future 2060 conditions with existing permits and full return flows.
- Scenario E: Future 2060 conditions with return flows and all recommended strategies.
- Scenario F: Full authorized diversions with no return flows.

The model output was used to determine effects from implementing the strategy on FTA for freshwater inflows into Galveston Bay for the Year 2060 condition. Monthly median freshwater inflows were determined for Scenarios A, B, C, D, E and F. The strategy models represent a Full Authorized Diversion scenario including expected return flows and strategies from upstream regions. **Figure 4-10** compares monthly medians, and shows median flows for the D and E models are lower than the naturalized flows but higher than the C (full diversions with limited return flows) model. This effect is partially due to including expected return flows (see the C model curve) and partially due to including water management strategies.

Median flows for the E model were also found to be slightly lower than current conditions for the majority of the year, but exceed current conditions for March, April, September and November. Freshwater inflows for the E model were also evaluated with reference to FTAs recommended by the TWDB and TPWD. For this modeling study, the recommended annual frequency was used as a placeholder for evaluating seasonal variations (i.e., monthly distribution). Targets were assumed to be attained for a period in which the flow met or exceeded the target.

Implementing WMS will impact the FTA and the proportion of inflow supplied by each basin. This is especially important given several strategies proposed involve interbasin transfers of water in the Trinity and San Jacinto Basins, which are the primary contributors to B&E flow. B&E inflows for the San Jacinto and Trinity Basins for several model runs are shown in **Figure 4-10**.

**Figure 4-10:**
**B&E Contributions from the San Jacinto and Trinity Basins**




As shown in **Figure 4-10**, for naturalized conditions and the current conditions model, B&E inflows are dominated by inflows from the Trinity River Basin. The proportion of flow provided by the Trinity River Basin is lower for the remaining models, including the C model (Full Authorized Diversions + expected return flows). However, implementing upstream WMS shown for the $D_0$ model causes an increase in Trinity Basin's relative contributions as compared to the C model. The proportion is slightly lower for the E model, demonstrating the Region H strategies slightly increase the proportion of water coming from the San Jacinto Basin. This is largely due to the proposed project, an IBT that provides 450 MGD of water into the San Jacinto system.

Releasing water from reservoir storage on a discrete basis would increase monthly B&E flows and is the least likely option to interfere directly with the water rights priority system. From a reservoir operations standpoint, this is equivalent to managing releases when shortages for a particular month are less than some specified level.

Such an operating scenario in which reservoir releases would be made to address only the smallest B&E target flow shortages would minimize the volume of reservoir releases needed to meet frequency goals and would decrease the possibility of reducing the firm yield of existing and future water rights. Other relevant conclusions from this Region H study related to the freshwater inflow impacts for the LBITP include the following.

- In general, including strategies upstream from and within Region H generally leads to a net increase in freshwater inflows into Galveston Bay from importing new water into the basin.

- Impacts from individual Region H water management strategies are relatively minor, except for water transfers from the Trinity River to the San Jacinto River basin, which resulted in a net increase in the attainment frequency for one month.

- Shortages in meeting Max H and Min Q-Sal targets generally occur in the spring, and shortages of meeting Min Q generally occur in the summer months.
- Removing return wastewater flows due to planned reuse projects in Region C (Dallas/Fort Worth area) was found to result in a 20 percent reduction in freshwater inflows from the Trinity River into Trinity Bay.

The principal conclusion from this study as related to the current environmental flow evaluation is the implementing water management strategies identified by the regional water plans, including LBITP and Trinity River upper basin return flows from the Dallas Metroplex (Region C), would help meet environmental flow planning criteria for Galveston Bay. Over the entire period of record, this is equivalent to a 20 percent contribution of B&E discharges from the Trinity Basin.

**Table 4-11** show of the seven major supply rights examined, six experienced a reduction in firm yield due to removing upper basin return flows from the model runs. These reductions in firm yield ranged from 34 to 54 percent, with the most significant reduction occurring during the annual diversion that occurred primarily in 1956, during the record drought. As such, the implementation of any future Region C water management strategy that reduces return flows to Region H will have the potential to substantially alter B&E flow regimes and the firm yield for water rights in the Trinity and San Jacinto River Basins.

**Table 4-11:**
**Minimum Annual Diversions (MAD) With and Without Upper Basin Return Flow (RF)**

| Basin | Description | Permit | E Model | | E Model without RF | |
|---|---|---|---|---|---|---|
| | | | MAD (ac-ft) | Min. Date | MAD (ac-ft) | Min. Date |
| Trinity | Houston Livingston | 940,800 | 940,800 | NA | 536,303 | 1956 |
| Trinity | *San Jacinto River Authority (SJRA)/Devers Run of River (ROR) | 58,500 | 58,285 | 1950 | 33,718 | 1956 |
| Trinity | *Houston/Dayton | 38,000 | 34,084 | 1956 | 15,846 | 1956 |
| Trinity | CLCND - Lake Anahuac | 39,613 | 9,317 | 1956 | 9,317 | 1956 |
| Trinity | *CLCND Fixed Right – CWA | 73,334 | 73,334 | NA | 43,207 | 1956 |
| Trinity | *SJRA - CLCND Fixed Right – CWA | 30,000 | 30,000 | NA | 17,322 | 1963 |
| Trinity | Livingston – TRA | 403,200 | 403,200 | NA | 264,408 | 1956 |

## 4.4 Floodplains and Floodplain Values

In accordance with the requirements of Executive Order 11988, Floodplain Management, as part of their public interest review, projects should avoid to the extent practicable, long- and short-term significant adverse impacts associated with occupying and modifying floodplains, as well as the direct and indirect support of floodplain development whenever there is a practicable alternative.

The evaluation of potential impacts on floodplains considered whether the Alternative 3A or the No Action alternative would cause any of the following conditions:

- Filling a floodplain in a manner that would expose people or structures to flooding;
- Constructing in a floodplain in a manner that would violate National Flood Insurance Program requirements or result in changes that would increase the flood elevation level associated with a 100-year flood event by more than one foot or would increase an existing floodway; and/or

- Constructing in a floodplain in a manner that would violate state or local floodplain management regulations by causing an increase of an existing 1-percent annual chance of flood elevation by more than 0.5 foot.

A hydrologic and floodplain analysis for the proposed project has been developed, and a summary of these analyses follows.

## 4.4.1 Floodplains

A 1 percent (100-year) floodplain, also known as a Special Flood Hazard Area on a Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM or floodplain map), is an area at risk for flooding from a bayou, creek or other waterway overflowing during a 1 percent (100-year) flood. Structures located in a 1 percent (100-year) floodplain have a minimum of a 1 percent chance of flooding in any given year. Statistically, structures located in a 1 percent (100-year) floodplain have a minimum of a 26 percent chance of flooding during a 30-year period of time. A mapped 1 percent (100-year) floodplain is also an area where land development can be regulated by a city or a county.

### 4.4.1.1 No Action

Implementing No Action would result in no modifications to the local floodplain or special flood hazard area and thus no permanent, direct or long-term effect on hydrology compared with baseline conditions.

### 4.4.1.2 Alternative 3A

Alternative 3A ROW is almost entirely outside of the flood hazard zone of major streams. The flood hazard zone that exhibits a one (1) percent chance of flooding in any given year as identified by a Flood Insurance Study (FIS) exhibits the greatest risk of inundation when a stream overflows its banks. The Alternative 3A canal conveyance extends through the watersheds of Gillen Bayou, Cedar Bayou and Luce Bayou. An approximate 1.3-mile segment of the Alternative 3A ROW in the vicinity of Parcel 50 traverses the outer edge of the Cedar Bayou floodplain hazard zone near the downstream end of the Alternative 3A ROW. Natural stream characteristics such as channel forming and reconditioning, gradually varies flow. This contributes to meandering, sediment transport through natural erosion, developing sediment bed-load which contributes to channel stability. Groundwater influenced base flows are missing from a water supply conveyance. The canal's is designed to be stable and not meander, because the ROW is finite and limited. Sediment will be eliminated as much as possible by moving the source water into a sedimentation basin almost immediately after being diverted from the river. The proposed LBITP conveyance virtually eliminates the potential for a floodplain as it is to be constructed on a relatively high ridge (Capers Ridge) and uses gravity flow for most of its length to Lake Houston.

Alternative 3A would have a permanent effect on the existing surface water overflows, except during the most severe (infrequent) rainfall events (i.e., greater than 100-year flood event). Although the area in the vicinity of the Lake Houston discharge is within the 100-year mapped floodplain, no increase in the floodplain's extent would occur due to proposed overland flow conveyance structures (i.e., ditches or siphons). Using drainage ditches parallel to the proposed canal would allow overland flow to be conveyed along the canal and discharged in such a way as to control and minimize the possibility for localized flooding.

The proposed Alternative 3A canal alignment would be almost entirely outside the mapped 100-year floodplain as designated by the National Floodplain Insurance Program (NFIP). A 100-year flood is calculated to be the level of flood water expected to be equaled or exceeded every 100 years based on an average probability estimate. The 100-year flood is more accurately referred to as the 1 percent annual exceedance probability flood, since it is a flood with a 1 percent chance of being equaled or exceeded in given single year. Similarly, a flood level expected to be equaled or exceeded every 500 years on average is known as a 500-year flood and has a 0.2 percent chance of occurring in given year.

Alternative 3A would have minimal effect on natural riverine overflow, except in the most severe (infrequent) precipitation events. The area in the Lake Houston discharge vicinity is within the 100-year mapped floodplain, but there would be no increase in the lateral extent of the mapped floodplain because overland flow would be conveyed along the canal and would not cross the canal alignment. Overland flow scenarios would be designed to convey the upgradient runoff volume across the canal alignment. It will also be designed to convey the amount of initial rainfall and runoff through overland flow on the siphon structures' downgradient side designed as mitigation. This would be accomplished by designing the Alternative 3A side ditches to permanently hold water which, in effect, would pre-charge the ditches with runoff volume. This design feature allows overland flow to continue across the canal alignment at the siphon structures' surface expression. A more detailed explanation about the design issues and modeling results used to identify siphon locations proposed as mitigation and included as part of Alternative 3A is provided below.

Arc-Hydro, an extension of ArcMap®, was used to calculate drainage lines for the area surrounding the Alternative 3A alignment using topographical information from a digital elevation model (DEM). Subbasin area boundaries were delineated from these drainage lines using a minimum 100-acre basin size. To determine break locations, only sub-basin areas intersected or affected by the proposed Alternative 3A alignment were examined in the HEC-HMS model.

The methods used to develop the inputs into the HEC-HMS model are the Soil Conservation Service (SCS) Curve Number Method and SCS Unit Hydrograph Method. The SCS Curve Number Method requires land use data visually estimated from aerial photographs. From the land use types, a weighted runoff coefficient was determined for each sub-basin area. ArcGIS was used to calculate the total area for each sub-basin.

The general design approach for Alternative 3A's siphon structures for handling overland sheet flow includes the concept that surface water flow would be conveyed across the canal alignment in areas outside the identified watershed divides. A few typical locations were modeled to provide results needed for siphon design. Modeling overland flow during extreme events in flat slope areas indicated a 3- to 4-inch increase in ponding upstream from the canal alignment may be possible with typically less than a day's duration after the rainfall event where natural drainage collects in low lying areas. The typical measured impact on the Alternative 3A canal alignment's upstream side for the 100-year event is an increased 3- to 4-inch depth for 5 to 16 hours. For the 2-year event, the modeled adjacent ditches and culvert crossings were shown to have sufficient capacity to meet the existing 2-year peak flooding depths.

For flat slopes in the overland areas, 3- to 4-inch increases in ponding may result in the standing water expanding laterally ±500 feet for less than a day. Agricultural areas adjacent to the forested areas would be impacted during an extreme event, but would not be affected by the short increase in shallow inundation. For more frequent events, such as the 2-year event, the modeling results indicate the parallel ditches and cross culverts structures have the capacity to convey the flow across the Alternative 3A canal with no increase in water surface elevation. More detailed modeling would be required during final design to allow for more refined crossing analysis and to explore possibilities to further reduce extreme event impacts. All siphon crossings are located where the natural drainage tends to be the most concentrated to avoid impacting or changing the natural drainage pattern. Much of the drainage in the Alternative 3A canal area is generated through sheet flow or very shallow concentrated flow which would be intercepted by ditches paralleling the canal. After overland flow has been carried across the Alternative 3A alignment, it would flow to the parallel ditch along the canal's downstream side so there is a lateral continuance of the natural sheet flow pattern to the extent possible.

The proposed CRPS would be located immediately adjacent to and on the north side of Capers Ridge. In general, the facilities would be above the 100-year floodplain, although approximately 0.34 acres is mapped within the 100-year floodplain.

The proposed CRPS intake structure would be built along the river's western bank, which encompasses approximately 6 acres of the 100-year floodplain. Earthen bank material along the river would be excavated to allow for the pump bays construction and placing the erosion protection. This excavation would add floodplain storage, but the CRPS construction and placing erosion protection would offset the gain in floodplain storage at the pump station. There would be no change to the floodplain along the Trinity River.

Potential impacts on the lower Trinity River main channel and its floodplain would result from construction and operation of the proposed pump station and headwall. These activities would involve dredging and filling across the river and its floodplain. Short-term temporary increases in suspended sediment concentrations, turbidity, and sediment deposition would be minimized by implementation of erosion control measures. Dewatering and excavation for the embankment foundation would release sediments and organic matter onto the floodplain and eventually into the river. Channel bed scour likely would result from local hydraulic effects at bridge piers if they are located nearby. Constriction scour could also occur at any culverts or other structures located within the floodplain, particularly if supercritical (high kinetic energy) flow conditions occur. Woody debris, if present, could be accompanied by sediment transport, turbidity, and deposition downstream.

Approximately 48 acres of the floodplain occurs along the canal alignment and at the proposed discharge point along Lake Houston. Of the 48 acres, approximately 45 acres occur along the canal alignment that extends approximately 12,000 linear-feet through the upper part of the Cedar Bayou watershed, identified as perennial and intermittent stream segments (**Chapter 2**) crossing through the southern part of Parcel 50 (Texas Land Fund No. 6, see **Chapter 5, Table 5-2**). Since the canal and sedimentation basin would be excavated features, constructing these features would not decrease floodplain storage. The approximately 3 acres of floodplain remaining within the proposed project ROW occur at the Luce Bayou discharge point for Alternative 3A. The proposed culverts would be constructed underground; would be covered with earthen material; and would not decrease floodplain storage compared to baseline or increase the amount of impervious cover; therefore, runoff volumes would represent baseline conditions.

With the exception of the canal that changes direction and extends into the Cedar Bayou watershed and floodplain, the proposed Alternative 3A ROW is almost entirely outside the 100-year floodplain of mapped surface water features. By interpreting the processed LiDAR data, the watershed boundaries between Luce Bayou and the Trinity River (the alignment's northeastern part) and Cedar Bayou (the canal alignment's southwestern part) were estimated. The proposed Alternative 3A ROW was modified to follow this ridgeline as closely as possible to eliminate cross-drainage effects and minimize the canal's impact on overland flow during extreme rainfall events.

#### 4.4.1.3 Alternative 4

There are approximately 102 acres of 100-year floodplains in the ROW of Alternative 4. Of these 102 acres, approximately 50 acres occur along the pipeline alignment that extends approximately 29,000 linear-feet through the Cedar Bayou watershed, with at least 75 percent of this sensitive area being identified as perennial and intermittent stream segments (**Chapter 2**). The surface expression of the proposed pipeline would include elevated access roads with drainage ditches and berms, and a mounded, fenced, mowed and maintained easement. Efforts would be made to minimize the potential descrease to floodplain storage and functioning, although it is expected that direct, permanent effects to floodplains may occur as a result of Alternative 4.

#### 4.4.1.4 Alternative 6

There are approximately 122 acres of 100-year floodplains in the ROW of Alternative 6. Of the 122 acres, approximately 48 acres occur along the pipeline alignment that extends approximately 28,133 linear-feet through the Cedar Bayou watershed, with approximately 50 percent of the bayou being identified as perennial and intermittent stream segments (**Chapter 2**). The surface expression of the proposed pipeline elevated access roads with drainage ditches and berms, and a mounded, fenced, mowed and maintained easement. Efforts would be made to minimize the potential descrease to floodplain storage and functioning, although it is expected that direct, permanent effects to floodplain floodplains may occur as a result of Alternative 6.

#### 4.4.1.5 Means to Reduce Effects and Mitigation

Based on studies performed during preliminary design, water surface elevations were established to understand effects on the 100-year flood estimates available through FEMA mapping. In keeping with common floodplain management practices, the design of canal and other project element crossings of flood resources were developed to limit increases in water surface elevations to within a specific level with reference to baseline conditions for the 100-year flood event. As a result, limited effects are anticipated to floodplain boundaries or to existing structures in or near the lower Trinity River, or within the floodplain of Cedar Bayou or Luce Bayou and other watersheds. Formal review of flooding and floodplain issues would be required to take place with designated floodplain management staff in Harris and Liberty counties, in compliance with the National Flood Insurance Program as well as with the Harris County Flood Control District (see Permit Report **Appendix N**).

Floodplain impacts caused by or related to Alternative 3A operations are not expected. Operational impacts along the canal conveyance, utility corridors, and CRPS would include periodic vegetation control, landscaping maintenance, canal and facility maintenance in the form of mowing, trimming, aquatic plant species removal, sediment removal and stockpiling, and raw water intake and discharge.

Alternative 3A canal design criteria mitigates against vegetation growth within the canal by developing a channel cross section which maintains water velocity at 2 f/s to limit plants ability to take root in the canal. Much of the canal will experience 5 f/s velocities, which will require hardened (concrete) lining or armoring the canal. The canal's design flow depth (7 to 8 feet) will limit sunlight penetration, thus eliminating the potential for aquatic plant photosynthesis (AECOM 2011).

Assuming the pumps at the CRPS are shut-down for an 8-hour maximum during a 100-year, 24-hour rainfall event, the extreme event analysis shows the canal has capacity to carry the event and maintain a minimum 1.2-foot freeboard flow. Should the pumps not be turned off during a 100-year event, the canal can convey the event with a minimum 0.3-foot freeboard flow. This minimum freeboard flow is most likely to occur within the portion of the proposed canal where the 11-foot depth is recommended.

With the Alternative 3A canal operating at its ultimate 774 cfs capacity, unsteady state modeling shows it would take approximately eight hours for the water level control gates to completely shut down the flow to Lake Houston after the pumps have been turned off. Returning the canal to the 774 cfs flow rate is shown to take approximately 13 hours. Flow begins to arrive at the outfall approximately three hours after the pumps have been turned on, assuming the water level control gates are holding water in the canal.

Site specific studies have been conducted for Alternative 3A, but not for Alternatives 4 or 6. Therefore the measures developed to reduce effects and proposed mitigation address Alternative 3A and it assumed that similar measures would be implemented for the other action alternatives as needed.

### 4.4.2 Floodplain Values

This section analyzes the effects from Alternative 3A on floodplain values and flooding in the proposed LBITP's vicinity, and addresses the changes to the affected surface water features and associated floodplains. The influence area for floodplains includes the proposed Alternative 3A ROW location including the proposed CRPS and intake structure, pipeline, sedimentation basin, conveyance canal, maintenance facility, and discharge structure plus the roads and utility lines (natural gas and electrical) necessary to support proposed operations.

Site specific studies have been conducted for Alternative 3A, but not for Alternatives 4 or 6. Therefore the measures developed to reduce effects and proposed mitigation address Alternative 3A and it assumed that similar measures would be implemented for the other action alternatives as needed.

#### 4.4.2.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur in or near floodplains, and there would be no impact or change in baseline conditions related to the potential for flooding.

Floodplain impacts caused by or related to Alternative 3A operations are not expected. Operational impacts along the canal conveyance, utility corridors, and CRPS would include periodic vegetation control, landscaping maintenance, canal and facility maintenance in the form of mowing, trimming, aquatic plant species removal, sediment removal and stockpiling, and raw water intake and discharge.

#### 4.4.2.2 Alternative 3A

In some areas, the proposed Alternative 3A canal would be elevated above ground level possibly causing the canal structure to impede natural drainage paths of overland and channelized flow unless otherwise controlled. The general design approach for the Alternative 3A siphon structures for handling overland sheet flow includes surface water flow being conveyed across the canal alignment in areas outside the identified watershed divides. A few typical locations were modeled to provide results needed for siphon design. As mitigation, a series of siphons in conjunction with collector ditches and culverts would be constructed along the Alternative 3A canal alignment ROW.

Based on studies performed during preliminary design, water surface elevations were established to understand effects on the 100-year flood estimates available through FEMA mapping. In keeping with common floodplain management practices, the design of canal and other project element crossings of flood resources were developed to limit increases in water surface elevations to within a specific level with reference to baseline conditions for the 100-year flood event. As a result, minimal impacts are anticipated to floodplain boundaries or to existing structures in or near the lower Trinity River, or within the floodplain of Cedar Bayou or Luce Bayou and other watersheds. Formal review of flooding and floodplain issues would be required to take place with designated floodplain management staff in Harris and Liberty counties, in compliance with the National Flood Insurance Program as well as with the Harris County Flood Control District (HCFCD—see Permit Report **Appendix N**).

#### 4.4.2.3 Alternative 4

Site specific studies have been conducted for Alternative 3A, but not for Alternative 4. Therefore the measures developed to reduce effects and proposed mitigation address Alternative 3A and it assumed that similar measures would be implemented for the other action alternatives as needed.

Based on studies performed during preliminary design, water surface elevations were established to understand effects on the 100-year flood estimates available through FEMA mapping. In keeping with common floodplain management practices, the design of canal and other project element crossings of flood resources were developed to limit increases in water surface elevations to within a specific level with reference to baseline conditions for the 100-year flood event. As a result, minimal impacts are anticipated to floodplain boundaries or to existing structures in or near the lower Trinity River, or within the floodplain of Cedar Bayou or Luce Bayou and other watersheds. Formal review of flooding and floodplain issues would be required to take place with designated floodplain management staff in Harris and Liberty counties, in compliance with the National Flood Insurance Program as well as with the Harris County Flood Control District (HCFCD—see Permit Report **Appendix N**).

#### 4.4.2.4 Alternative 6

Site specific studies have been conducted for Alternative 3A, but not for Alternative 6. Therefore the measures developed to reduce effects and proposed mitigation address Alternative 3A and it assumed that similar measures would be implemented for the other action alternatives as needed.

Based on studies performed during preliminary design, water surface elevations were established to understand effects on the 100-year flood estimates available through FEMA mapping. In keeping with common floodplain management practices, the design of canal and other project element crossings of flood resources were developed to limit increases in water surface elevations to within a specific level with reference to baseline conditions for the 100-year flood event. As a result, minimal impacts are anticipated to floodplain boundaries or to existing structures in or near the lower Trinity River, or within the floodplain of Cedar Bayou or Luce Bayou and other watersheds. Formal review of flooding and floodplain issues would be required to take place with designated floodplain management staff in Harris and Liberty counties, in compliance with the National Flood Insurance Program as well as with the Harris County Flood Control District (HCFCD—see Permit Report **Appendix N**).

#### 4.4.2.5 Reduction and Mitigation of Potential Impacts

The Public Notice for Permit Application No. SWG-2009-00188 provided a review for the Section 404 IP Sketches (Sheets) numbered 1 through 44 (**Appendix S**). The locations for the proposed siphons are provided as shown on Sheets 12-32 (note “siphon” designation on sheets). Sheet 38 shows the cross-section and plan view for the siphon structures that eliminate hydrology changes and provide opportunities for safe wildlife crossings.

For all alternatives, avoidance of floodplains, including the Cedar Bayou floodplain and flood hazard areas should occur. In keeping with common floodplain management practices, the design of canal, pipeline, access roads, pump stations, and other project element that would involve crossings of flood resources would be developed to limit increases in water surface elevations to within a specific level with reference to baseline conditions for the 100-year flood event. As a result, minimal impacts are anticipated to floodplain boundaries or to existing structures in or near the lower Trinity River, or within the floodplain of Cedar Bayou or Luce Bayou and other watersheds. Formal review of flooding and floodplain issues would be required to take place with designated floodplain management staff in Harris and Liberty counties, in compliance with the National Flood Insurance Program as well as with the Harris County Flood Control District (HCFCD—see Permit Report **Appendix N**).

Changes in floodplains and floodplain values would not occur due to Alterative 3A’s operation. The proposed Alternative 3A canal would have side berms and access roads paralleling the canal which would contain an approximate 7-foot water depth. Eighteen siphon structures would convey Alternative 3A water in the canal below the ground surface through concrete box culverts. These siphon structures would maintain local hydrologic and drainage systems allowing sheet flow conveyance to go overland. The surface expression for the siphons which would convey drainage includes ditches, swales and 200-foot-long by 300-foot-wide open grassy areas.

The proposed Alternative 3A siphons are proposed to be located along the canal alignment in undeveloped areas at points determined through hydraulic analyses to require overland flow conveyance to avoid impacts to local hydrology. These siphon structures would not be located at pipeline, utility easements, or roadway crossings, and would allow safe wildlife passage across the proposed approximately 23-mile Alternative 3A canal conveyance structure. The siphon structures would be covered with grass and would primarily be at ground level with a small swale to allow for drainage across the canal ROW. The canal alignment and siphon locations would be fenced with barb-wire along the Alternative 3A ROW boundaries.

Wildlife concerns and criteria for construction project fencing would be considered during LBITP's final design. Along the Alternative 3A pipeline and at utility easements and roadway crossings located away from the siphon and wildlife crossing areas, chain-link fences approximately 6 to 8 feet above the ground surface would be constructed for motorist and pedestrian safety.

## 4.5 Waters of the United States, Including Wetlands

### 4.5.1 Waters of the United States

The area directly influenced by the proposed LBITP and waters of the United States, including wetlands, includes the potential location for the ROW proposed for Alternatives 3A, 4 and 6 including roads, pipeline, canal with access roads and fencing, pump and discharge stations, sedimentation basin, maintenance facility and utility lines.

Wetland impacts associated with all action alternatives were identified by superimposing field-delineated wetlands onto geo-rectified aerial photographs and satellite imagery displaying the proposed power station infrastructures and ROWs. NWI mapping was used to supplement and identify potential wetlands and other waters in areas where access was not granted. GIS applications were then used to determine area calculations for delineated and potential wetlands that would potentially be impacted by Alternative 3A.

An investigation for U.S. waters was performed on the proposed Alternative 3A ROW and CRPS property. The investigation identified waters which would be impacted by the project's construction, operation and maintenance. The preliminary jurisdictional determination process has been implemented for Alternative 3A. During the investigation, identified natural drainage features were considered jurisdictional. Man-made upland drainage ditches and ponds excavated from uplands were identified as non-jurisdictional. The investigation resulted in identifying and delineating jurisdictional aquatic resources.

The influence area for wetland resources included Alternative 3A's proposed ROW for including associated infrastructure (i.e., pump station, pipeline ROW, sedimentation basin, conveyance canal, and discharge facility).

Impacts to wetlands and other U.S. waters were identified by overlaying the surveyed wetlands and wetlands shown by the NWI maps over graphic illustrations depicting the proposed Alternative 3A ROW. Wetland impacts were characterized as the direct loss of wetlands due to placing dredge or fill material, and as type conversion impacts, relating to the altering or converting wetlands function due to removing vegetation. These type conversion impacts could be temporary (e.g., where an emergent or scrub-shrub [woody vegetation less than 20 feet tall] wetland is disturbed and allowed to regenerate) or permanent (e.g., a wetland forest is cleared and allowed to regenerate as an emergent or scrub-shrub wetlands).

The acreages for wetland areas affected by Alternative 3A and related infrastructures were calculated using GIS. The wetland types affected were identified based on field observations or by NWI mapping (sometimes supplemented by soils mapping and aerial photographs). Activities involving dredging material from U.S. waters including wetlands or placing fill in wetlands, would be considered to have an adverse impact. Dredged material is defined as material that is dredged or excavated from U.S. waters including wetlands. Fill material is defined as material placed in U.S. waters where the material either replaces portion of such waters with dry land or changes the bottom elevation of a portion of such waters. Activities involving removing or converting wetland vegetation, but do not include grubbing stumps or roots or disturbing soils, could affect wetland resources. A direct loss of wetlands would not occur in this case. However, if a change in the wetland function would occur by converting wetland type (i.e., forested wetland conversion to emergent wetland) the result would be an adverse impact. Permanent impacts to wetlands can be quantified by determining areas that would not experience fill but would be anticipated to experience removal and routine vegetation maintenance.

#### 4.5.1.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated, as a result, there would be no direct or indirect impact or change to the waters of the United States identified within the ROW of Alternatives 3A, 4 and 6.

#### 4.5.1.2 Alternative 3A

Alternative 3A Waters of the United States, including Wetlands data are based on site-specific studies conducted for this alternative. Approximately 2.15 acres of U.S. waters were identified during field investigations. Of these acres, approximately 0.18 acre has small, natural drainage features exhibiting an OHWM. The remaining 1.97 acres would be composed of the Lake Houston and Luce Bayou confluence (0.30 acre) and the Trinity River (1.67 acres).

The approximate 0.18 acre with small, natural drainages would be excavated within the ROW of Alternative 3A. Flows from the portions of these drainages outside the project footprint would be directed into a small drainage ditch within the project ROW. Alternative 3A's canal component would flow into underground siphons at 18 locations. Small drainage swales would cross the canal and flow into drainage ditches. Flows would be directed back to ditches within the ROW and returned to the drainages to continue in the original flow direction.

CRPS would be constructed at the Trinity River, and the construction would include impacts below the Trinity River's OHWM. Approximately 1.67 acres of the Trinity River would be impacted during construction. Impacts would include placing a trash rack, constructing a headwall and concrete slope protection at the headwall's base, placing a sluice gate in the headwall, constructing an intake structure, and placing riprap for erosion protection. Excavation needed to construct the pump station and associated erosion protection would also occur below the OHWM.

Approximately 330 cubic yards of concrete slope protection (including headwall and concrete toe) and an additional approximate 470 cubic yards of backfill material would be placed below the OHWM at the proposed pump station. This would allow constructing the sluice gate, trash rack and headwall wall for the pump station. Approximately 1,100 cubic yards of material would be excavated below the OHWM to allow for pump station construction and placing the concrete slope protection and headwall. Riprap would also be placed along Trinity River banks upstream and downstream from the intake structure for erosion protection. About 7,600 cubic yards of riprap would be placed below Trinity River's OHWM. To allow riprap placement, about 6,000 cubic yards of material would be excavated below Trinity River's OHWM.

The proposed canal would discharge into Lake Houston's backwaters along the northeast shoreline downstream from the confluence with Luce Bayou. The canal would discharge below the OHWM through three 6-foot by 8-foot box culverts, which would terminate at a concrete headwall. Through erosion analysis, it was determined erosion protection is needed at the discharge point. Approximately 975 cubic yards of riprap would be placed below the OHWM. Constructing the concrete headwall and placing erosion protection would impact approximately 0.30 acre below the OHWM.

As discussed in **Chapter 4.2.5**, temporary soil erosion and sedimentation controls would be implemented prior to and during the proposed project's construction. Short-term increases in water turbidity, and associated decreases in water clarity, would be expected during Alternative 3A's construction activities. However, suspended sediments should settle from the water column as construction activities are completed and soils are stabilized. During operation, some increase in turbidity could occur in the pump station's immediate vicinity (Trinity River) and ate the outfall (Luce Bayou). About 0.30 acre of Luce Bayou influenced by Lake Houston's water level elevation and about 1.67 acres of the Trinity River would be dewatered. This would result in a temporary loss of open water habitat. After construction is complete, the temporary sheet piles would be removed, which would allow the dewatered area to be re-submerged so no additional effects would be expected.

#### 4.5.1.3 Alternative 4

Data for Alternative 4 is based on NWI and 100 year floodplain data An approximate total of 38 stream crossings were identified within the Alternative 4 corridor including 33 canal ditches, four intermittent streams/rivers and four perennial streams/rivers **(Figure 3.3.2-2)**. Stream crossings for Alternatives 4 were identified through a review of the USGS National Hydrography Flowlines (**Figure 4-11**).

#### 4.5.1.4 Alternative 6

Data for Alternative 6 is based on NWI and 100 yr floodplain data An approximate total of 33 stream crossings were identified within the Alternative 6 ROW corridor including 25 canal ditches, three intermittent streams/rivers and three perennial streams/rivers and three articificial paths **(Figure 3.3.2-3)**. Stream crossings for Alternatives 6 were identified through a review of the USGS National Hydrography flowlines dataset (**Figure 4-12**).

### 4.5.2 Wetlands

The influence area for wetland resources included the proposed ROW for Alternative 3A including associated infrastructure (i.e., the proposed CRPS, the pipeline ROW, sedimentation basin, conveyance canal ROW and discharge facility). The influence area for wetland resources included the proposed ROW for Alternatives 4 and 6 including associated infrastructure (i.e., the proposed CRPS, TRPS, pipeline ROW, sedimentation basin, and discharge facility).

National Wetland Inventory (NWI) and 100-year floodplain data were used to identify wetlands and water resources located within the ROW of Alternative 3A, Alternative 4, and Alternative 6.

For the Applicant's preferred Alternative 3A, the USACE preliminary jurisdictional determination method was used for whereby all waters and wetlands identified within the ROW corridor, except man-made ditches, farmed wetlands, and ponds, are treated as regulated waters under Section 404 of the Clean Water Act. The USACE has not verified the jurisdictional status or locations and boundaries of these resources at this time. Coordination with the USACE is ongoing and will continue until a Department of the Army permit for the proposed project is issued.

To help identify wetland areas, advanced GIS processing of high resolution topography data was used to assess wetland hydrology along the proposed Alternative 3A LBITP alignment. Forested wetland hydrology has been difficult to study with conventional remote sensing methods, and collecting this data in the field is often cost prohibitive. Aerial photographs have typically been used to help identify wetland areas, but the ability of these data sets to detect hydrology is limited, especially in forested areas. High resolution topography datasets, such as remote sensing Light Detection and Ranging (LiDAR), offer the ability to identify local variations in topography and hydrology of potential wetlands areas beneath the forest canopy to provide planning level data for decision-making.

As part of the preliminary assessment during Alternative 3A's development, high resolution LiDAR topography data was collected for the proposed alignment between the Trinity River and Lake Houston. This topography data was processed using the fill sinks grid processing tool inside the Arc Hydro extension for ArcGIS version 9.3. The fill sinks function analyzes an elevation grid and identifies depressions or sinks where water collects and is unable to flow downhill. These sinks or depressions represent a disjointed wetland hydrology and indicate continually wet soils and the likely presence of wetland ecosystems. The fill sinks function determines the extent of these sinks or depressions by determining the ponding elevation and spread inside each sink which would result in overtopping the depression and the continued flow of water downhill towards a receiving stream. Areas showing as large depressions represent pervasive wetlands, while areas with a dense concentration of small independent sinks represent a more dispersed mosaic wetland.

Comparing field determined wetland areas and LiDAR determined wetland areas on the Harrison tract showed significant improvements in digitally identifying wetland areas compared to analyzing aerial photos alone. Furthermore, the analysis proved to identify predominant wetland features with a high degree of accuracy while also showing the presence of more moderate or mosaic wetlands.

#### 4.5.2.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur in or near wetlands, and there would be no impact or change in baseline conditions related to these resources.

#### 4.5.2.2 Alternative 3A

The major hydrology source for wetlands identified in the Alternative 3A canal's vicinity is precipitation. Wetlands bisected by the proposed canal and occur inside and partially outside the Alternative 3A ROW could potentially be impacted by the proposed project. Wetlands outside the Alternative 3A alignment that may depend on hydrology from surface water flow are not anticipated to be affected by Alternative 3A. In addition to the canal alignment's direct impacts on wetlands resources, the Alternative 3A canal side berms present potential impediments to overland flow; some may supply runoff to wetlands away from the alignment. Most wetlands outside the 100-year floodplain are expected to be depressional in nature, and to have direct precipitation as a hydrology source.

Investigations into the nature and extent of wetlands resources were performed on the proposed Alternative 3A ROW and the CRPS area. These investigations identified U.S. waters including wetlands which would be impacted by the project's construction, operation, and maintenance. Wetland impacts associated with Alternative 3A were identified by superimposing field-delineated wetlands onto geo-rectified aerial photographs and satellite imagery displaying the proposed Alternative 3A ROW. The National Wetland Inventory (NWI) mapping performed by the USFWS was used to supplement and identify potential wetlands and other waters in areas where property access was not granted. GIS applications were then used to determine area calculations for delineated and potential wetlands which would potentially be impacted by Alternative 3A.

The preliminary jurisdictional determination (PJD) process has been implemented for Alternative 3A ROW. During the investigation, identified wetland features were considered jurisdictional. Man-made upland drainage ditches and ponds excavated from uplands were identified as non-jurisdictional. The investigation resulted in identifying and delineating jurisdictional aquatic resources.

Based on the PJD, approximately 203 acres of freshwater aquatic resources were identified within Alternative 3A ROW. Of this total, approximately 118.93 acres are forested wetlands, 45.26 acres are emergent wetlands, 11.21 acres are open water, and 25.55 acres are scrub-shrub wetlands. Clearing the Alternative 3A ROW would require using mechanized land clearing equipment, which is considered a regulated fill activity. Project-related construction activities would result in adverse impacts to the freshwater wetlands within the Alternative 3A ROW; thus, adding to the continued decline of freshwater wetlands within the total conterminous United States, especially for freshwater forested wetlands. Mitigation for the impacts to wetlands is discussed below.

Delineated wetland areas for Alternative 3A meet the three criteria of a wetland (wetland hydrology, hydrophytic vegetation, and hydric soils). Vegetation types within these wetlands range from pine-hardwood forest to open pasture. Vegetation is described in detail below.

The potentially non-jurisdictional resources do not have a connection to any other potentially jurisdictional aquatic feature, including wetlands, and do not follow topographical gradients. The man-made ditches occur mostly within agricultural areas and appear to function as irrigation ditches. The ponds appear to have been excavated out of uplands and serve as a supplemental water source for livestock. Non-tidal drainage ditches and excavated ponds created out of uplands are generally not subject to regulation by the USACE pursuant to Section 404 of the Clean Water Act.

Wetlands that are bisected by the proposed canal and occur inside and partially outside of the Alternative 3A ROW could potentially be impacted, although the proposed siphons have been designed to minimize and eliminate impacts related to changes in hydrology. Siphon conveyance of the Alternative 3A canal in below-grade culverts was designed to provide hydrologic connection of wetlands resources and thereby avoid degradation that may occur through construction of the canal. The major source of hydrology for wetlands identified in the vicinity of the Alternative 3A canal is precipitation. To minimize degradation that could occur due to an interruption of overland flow, eighteen drainage crossings are proposed to be included in the canal design to maintain areas of hydrologic connection.
The AJD process was implemented for the proposed mitigation property in 2012.

Site-specific assessments for wetland functions and values have been conducted to determine compensatory mitigation requirements for impacted wetlands. Wetland functions and values would be temporarily or permanently lost from constructing proposed project. These functions might include food chain support, habitat, flood control, and nutrient/pollutant retention. The degree and magnitude of these impacts on the wetlands' functional capacity would be less quantifiable than activities resulting in direct fill material placement. The wetlands function and value assessments and proposed compensatory mitigation are discussed in detail in **Chapter 5**.

#### 4.5.2.3 Alternative 4

Based on desk-top studies conducted, of the approximate 66 total wetland acres in the ROW of Alternative 4, approximately 18 acres are Freshwater Emergent Wetlands, 46 acres are Freshwater Forested/Shrub Wetland and 2 acres are Lakes **(Figures 3.5.1-2a** through **Figure 3.5.1-2d.**

#### 4.5.2.4 Alternative 6

Based on desk-top studies conducted, of the approximate 82 total wetland acres in the ROW of Alternative 6, approximately 6 acres are Freshwater Emergent Wetlands, 71 acres are Freshwater Forested/Shrub Wetland, 2 acres are Freshwater Ponds, 1 acres are Lakes, and 2 acres are Riverine **(Figures 3.5.1-3a** through **Figure 3.5.1-3d.**

### 4.5.3 Reduction and Mitigation of Potential Impacts

An approximate 3,000-acre property near the Trinity River including Capers Ridge has been identified by the Applicant and is being investigated for compensatory mitigation. Coordination with the Corps-Galveston District regarding mitigation is ongoing.

To minimize degradation due to an interruption of overland flow, 18 drainage crossings are proposed to be included in the canal design to maintain hydrologically connected areas.

Activities that would indirectly alter a wetland's hydrology, such as increased impervious surface adjacent to wetland areas or altering and/or diverting surface water flows to or from the wetlands, would also be considered to cause impacts. In this case, a change in the hydrological regime would either increase the amount of existing wetlands or cause existing wetlands to convert to upland communities. However, overland flow scenarios described as mitigation in **Section 4.2** would be designed to convey the upgradient runoff volume across the Alternative 3A canal alignment, and the initial rainfall amount and runoff through overland flow on the siphon structures' downgradient side. This would be accomplished by designing the Alternative 3A side ditches to permanently hold water which, in effect, would pre-charge the ditches with runoff volume. This design feature allows overland flow to continue across the canal alignment at the proposed mitigation using siphon structures. Wetlands that depend on runoff for hydrology which are adjacent to but not directly impacted by the Alternative 3A ROW would not be significantly impacted by the canal conveyance system.

The degree and magnitude of these impacts on the wetlands' functional capacity would be less quantifiable than activities resulting in the directly placing fill materials.

## 4.6 Vegetation and Wildlife

### 4.6.1 Vegetation

The area directly influenced by the proposed LBITP (any action alternative) for terrestrial vegetation and wildlife includes the proposed ROW for each alternative including the location of roads, pipeline sections, canal alignments, pump and discharge stations, sedimentation basins, maintenance facility and utility lines. Riparian ecosystems occur along project area surface water features including Cedar Bayou, Luce Bayou, and the lower Trinity River and especially in floodplains. The riparian corridor encompasses the stream channel and that portion of the terrestrial landscape from water's edge landward, where vegetation may be influenced by river-influenced water tables or flooding, and by the ability of soils to hold water. Riparian vegetation refers to the vegetation growing within the riparian corridor. Since riparian settings are interfaces between terrestrial and aquatic systems, ecological processes in those settings are dependent on both the dynamics of the associated uplands and the streams.

Riparian vegetation plays an important role in water quality functions of riverine systems and influences other biologically important water quality parameters such as dissolved oxygen and temperature. Riparian vegetation is an important component of the aquatic faunal habitat and these effects include (a) provision of fish cover (b) provision of streambank stability (c) regulation of stream temperatures (d) input of nutrients to the system and (e) direct input of invertebrates as fish food.

The structure and function of vegetation of the study area's humid riparian are dominated by overland flows. Large, complex floodplains have developed, along the lower Trinity River especially near the coast, and there are a large percentage of wetlands in that area. Riparian vegetation varies by type, size and distribution and the distribution patterns of riparian vegetation depend on moisture gradients (flooding and depth to groundwater), fluvial geomorphic landforms, and stream gradients. These riparian areas provide critical wildlife habitat in many landscape settings. Riparian vegetation provides support for many wildlife requirements. The value of riparian areas of the lower Trinity River and upper Galveston Bay watersheds, including Cedar Bayou and Luce Bayou, are related to their size and contiguity and are most valuable when they remain intact and form a continuous corridor for wildlife migration. Intact riparian vegetation areas are valuable and provide significant ecosystem benefit, although fragmented habitat in areas where otherwise not present function as valuable habitat to increasingly stressed wildlife. Flood attenuation is also increased in vegetated riparian systems in areas with maintained stream morphology through vegetative anchoring.

A water supply conveyance contrasts with natural stream by supporting habitat for aquatic organisms. Natural streams tend to maintain a dynamic balance between aquatic organism populations and available food. The population dynamics of aquatic animal communities in stream ecosystems involve using substrate, the food web, nutrient spiraling and the growth curve. Organic waste substances in streams form the substrate on which microorganisms grow and become part of the food web. Nutrients circulate from surface-to-substrate as they flow downstream and are available to bacteria, algae, fungi, invertebrates, fish and other aquatic organisms. The circulation capture, release and recapture cycle for nutrients is called nutrient spiraling. A stream's ability to assimilate nutrients and store them in the living tissue of plants and animals is termed its assimilative capacity. The higher this assimilative capacity in a natural stream the higher the streams' water quality. In a constructed conveyance canal, several essential pre-conditions for supportive habitat and the in stream balances characterizing natural streams are intentionally eliminated. As previously mentioned, aquatic food sources including primary productivity through plant detritus would be eliminated in a constructed canal. Sediment transport and eliminating a variety of nutrients reduces or eliminates nutrient spiraling, and the conveyance channel essentially has no assimilative capacity.

#### 4.6.1.1 Analysis Method

Vegetation and land cover types within the Alternative 3A ROW were identified and described in Section 3.9 based on the National Land Cover Database of 2006 (NLCD 2006) and the results from field investigations conducted by biologists. NLCD 2006 is a 16-class land cover classification scheme for the conterminous United States and was developed at a spatial 100-foot resolution. NLCD 2006 is based primarily on the classification of Landsat Enhanced Thematic Mapper+ (ETM+) circa 2006 satellite data. These data were used with GIS analyses of aerial photography and the results from field investigations to initially determine the vegetation/land cover types directly affected by constructing Alternative 3A. The analyses conducted included quantifying the total number of acres within the Alternative 3A ROW by vegetation type (**Table 3-15**). Since the above analyses were conducted, Phase I and Phase II of the Ecological Systems Classification and Mapping Project in support of the Texas Comprehensive Wildlife Conservation Strategy have been conducted and the results published (TPWD 2012 and TPWD in progress). These latest state-wide efforts at vegetative classification have been integrated into the Habitat Evaluation Procedure (HEP) conducted by Corps, Galveston District to address public scoping comments, the alternatives analysis presented in **Chapter 2** of this DEIS, and the vegetative type effects analyses conducted for Alternative 3A.

To evaluate the function and habitat value represented by the vegetative and use type within the Alternative 3A ROW, a HEP was conducted, as directed by Corps, Galveston District to address public comment received in response to the Public Scoping Meeting held on Thursday, July 21, 2011 for the LBITP Draft EIS (DEIS). The generalized process for conducting a HEP study involves the following components (USFWS 1980):

- Determine HEP's applicability and define the study area

- Delineate habitat or vegetation cover types
- Select the relevant evaluation species
- Determine each species' life requisites
- Measure habitat variables for suitability
- Determine baseline and future habitat units
- Develop compensation/mitigation plans for the proposed project

The HEP is a habitat-based evaluation method developed by USFWS in 1974 for use as an analytical tool in impact assessments and project planning. HEP is used to evaluate the species and potential habitat present based on an area's ecological value analysis. The approach is to quantify the value of habitat available to a selected wildlife species set within a specified geographic interest area. The method is designed to describe wildlife habitat values at baseline and future conditions to allow for comparisons of the relative values of different areas at the same point in time or of the same area at different points in time. Because HEP provides a quantitative method for such comparisons, it may be used to assess current and future wildlife habitat or compensation analyses.

HEP appraises a study area by quantifying its habitat value, calculated as the product of habitat quantity and habitat quality. This value is expressed in Habitat Units (HU). Habitat quantity is simply the total habitat area available within the study area, usually expressed in number of acres. Available habitat within the study area may be subdivided into cover types or distinct areas with similar ecological characteristics which are adequately homogeneous. If the study area is subdivided into cover types, habitat quantities used in the evaluation may be subsets of the study area. Habitat quality is expressed in terms of a Habitat Suitability Index (HSI), which is determined by comparing the study area's ecological characteristics to the optimum habitat characteristics for the evaluation species. Evaluation species are representative wildlife species with known habitat requirements selected to provide the basis for assessing habitat suitability.

HSI values are based on two components: the habitat characteristics providing ideal conditions for an evaluation species, and the habitat characteristics existing in the study area. These characteristics are described by a set of measurable habitat variables such as the height and percent cover for various vegetation types, the distance to water or food, the availability of perching or nesting sites, or flooding frequency. The habitat variables set needed to determine HSI values is obtained from documented habitat suitability models for each evaluation species. These models describe each species' life requisites, the relationship between the values for habitat variables, the area's suitability to meet its life requisites, and the method to integrate these suitability relationships into an HSI value. HSI values range from zero (0.0) to one (1.0), with zero representing unsuitable conditions and 1.0 being optimal conditions.

Habitat values may be calculated for each evaluation species within its available habitat or for each cover type within the study area. Calculations based on existing ecological conditions can be used to describe baseline conditions and serve as a reference point for comparison to predicted future habitat values with or without proposed actions or mitigation measures.

HEP provides a consistent means for assessing project impacts by demonstrating, in HUs gained or lost, the beneficial or adverse impacts anticipated as due to various courses of action. HEP aids mitigation analysis by identifying which factors negatively impact habitat values in various scenarios, thus suggesting means for improving habitat or selecting mitigation lands.

#### 4.6.1.2 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur and there would be no direct or indirect impact or change to the existing vegetation/land cover types or to wildlife habitats within the Alternative 3A ROW.

### 4.6.1.3 Alternative 3A

Alternative 3A begins in central Liberty County, Texas, extends along Capers Ridge from the Trinity River intake structure and terminates in northeast Harris County, Texas near the East Fork of the San Jacinto River and Lake Houston confluence. Alternative 3A is approximately 26.5 miles long and would encompass approximately 1,050 acres within a 300-foot wide ROW. The existing habitat within Alternative 3A's ROW includes forested areas, terrestrial wetlands, agricultural land, grazing land and public land (road ROW).

Based on the NLCD 2006 database and field investigations including those conducted to perform the PJD along the Alternative 3A ROW, seven terrestrial vegetation types were identified within the Alternative 3A ROW:

- Upland woodlands (forest)
- Mosaic/transitional woodlands (mixed forest)
- Agricultural fields (row crops)
- Pasturelands (pasture and hay)
- Scrub-shrub vegetation
- Wetlands and hydric communities (woody and emergent herbaceous wetlands)
- Open water

Based on this vegetative and land use classification scheme (see **Chapter 3** for definitions), the dominant vegetative type directly and permanently impacted by the construction and operation of Alternative 3A is upland woodlands (32 percent) within the 300-foot Alternative 3A ROW, closely followed by agricultural fields (28 percent). **Table 4-12** summarizes the direct permanent impacts to vegetation and land cover.

**Table 4-12:**
**Terrestrial Vegetation within Proposed Alternative 3A ROW**

| Terrestrial Vegetation/Land Cover Type | Acres |
|---|---|
| Upland Woodlands | 338 |
| Mosaic/Transitional Woodlands | 25 |
| Agricultural Fields | 286 |
| Pasturelands | 135 |
| Scrub/Shrub | 40 |
| Terrestrial Wetlands and Hydric Communities | 200 |
| Open Water | 26 |
| **Total** | **1,050** |

The TPWD's *Ecological Systems Classification of Texas Project* grew from a recognized need to provide better land cover classification and mapping for the state to facilitate improved planning and management. The original satellite-based land cover map was produced by the Texas Parks and Wildlife Department in 1984 (McMahan et al. 1984). As described above, that map series was updated by more recent products, including the latest NLCD (http://landcover.usgs.gov/uslandcover.php), the USGS GAP Analysis dataset (http://gapanalysis.nbii.gov/portal/server.pt), and the national LandFire map (http://www.landfire.gov). All the recent maps resulted in 30-meter resolution datasets, appropriate for planning at regional and statewide resolution scales. The national gold standard is NLCD (developed using circa 2001 satellite data), which recognized fewer than 20 land cover types statewide. None of these efforts have produced maps generally useful at a county level or below. The goal of the *Ecological Systems Classification of Texas Project* was to produce a map with a useful spatial resolution at a

1:24,000 scale (1 inch = 2,000 feet, the same scale as a USGS 7.5-minute quadrangle map) which would also contain a sufficient number of land cover and vegetative classes (thematic resolution) to provide improved insights for planning and management at a sub-county, or large ownership resolution scale. The referenced map was produced by first classifying the land cover, and then using ancillary data (e.g. hydrology, environmental data, highways and cities) to model final mapped vegetation types. The first step resulted in 15 base land cover classes, whereas the second step resulted in identifying 109 mapped vegetation types across Texas. These efforts provide planning level vegetative classifications at a 30-foot resolution with approximately 10 times more land cover classes than previous vegetative mapping efforts that resulted in similar type maps. This modified ecological systems classification scheme also explicitly incorporates vegetation dynamics and therefore facilitates better ecological interpretations for the biologist and planner. Newly identified remote sensing classification techniques were integrated into the analyses conducted; the result is a vegetative type classification map based on meticulous data analyses which is usefully interpretative, consistent across geopolitical boundaries, and flexible enough to achieve the desired vegetative analyses needed whether the need is defined at the local, regional or state planning levels. Phase I and Phase II of the *Ecological Systems Classification and Mapping Project* in support of the *Texas Comprehensive Wildlife Conservation Strategy* is incorporated by reference to this DEIS.

The vegetative data produced during Phase I and Phase II of the *Ecological Systems Classification and Mapping Project* were analyzed using GIS software, polygon development, and spatial overlay techniques to facilitate vegetative interpretation. From the Alternative 3A ROW centerline, a polygon representing the 300-foot wide Alternative 3A ROW was created using ArcMap©. The clipped raster image was converted to the polygon layer and analyzed spatially using a GIS program to aggregate the TPWD vegetation data within the Alternative 3A ROW. Based on the referenced classification scheme, Open Water includes water supply reservoirs (i.e., Lake Livingston and Lake Houston), bays, large ponds (i.e., irrigation ponds), canals and the Gulf of Mexico, plus large rivers such as the East Fork San Jacinto River and the Trinity River. Of special note, the *Ecological Systems Classification and Mapping Project* identified riparian areas as the vegetative type located within 30 meters (approximately 133 feet) of streams which are themselves identified as streams by the National Hydrology (NHD) Dataset (http://nhd.usgs.gov/data.html). This system also classified high and low intensity Urban Cover with a minor area of low intensity Urban Cover identified near the proposed Alternative 3A maintenance facility along SH 321.

Based on the *Ecological Systems Classification of Texas Project* data analyses within the Alternative 3A ROW, excluding the CRPS, many vegetative types were identified as summarized in **Table 4-13**. **Table 4-12** summarizes direct permanent impacts to vegetation described by the *Ecological Systems Classification of Texas Project* within the Alternative 3A ROW.

**Table 4-13:**
**Alternative 3A Vegetation Type from**
**TPWD Ecological Systems Classification and Mapping Project**

| Common Name | Description | Alternative 3A (acres) |
|---|---|---|
| Chenier Plain: Mixed Live Oak/Deciduous Hardwood Fringe Forest | Generally occurs over wet soils and may include coastal live oak or loblolly pine mixed with deciduous species, or in some places southern magnolia. Deciduous trees may include laurel oak, water oak, willow oak, cherrybark oak, sweetgum, Hercules-club pricklyash, Chinese tallow, and post oak. | 23.0 |
| Row Crops (Agricultural Fields) | Includes all cropland where fields are fallow for some portion of the year. Some fields may rotate into and out of cultivation frequently, and year-round cover crops are generally mapped as grassland. | 284.0* |

| Common Name | Description | Alternative 3A (acres) |
|---|---|---|
| Gulf Coast: Coastal Prairie | A variety of grasslands are circumscribed by this mapped type, and species such as Bermudagrass, Bahia grass, rat-tail smutgrass, broomsedge bluestem, busy bluestem, brownseed paspalum, and little bluestem may be dominant. Shrubs such as baccharis, Chinese tallow, or mesquite may be present. | 176.45 |
| Gulf Coast: Coastal Prairie Pond Shore | Herbaceous or sparse woody cover is characteristic, and species such as sedges, rushes, switchgrass, bushy bluestem, maidencane, and emergent aquatics may be important. Woody species such as Chinese tallow, sweetgum, water oak, sugar hackberry, rattlebox senna may also form sparse overstory cover. | 12.0 |
| Marsh | A variety of small areas of wet soils or alternately wet and dry soils, often near tanks or ponds, are represented within this type. Herbaceous species such as cattails, spikerushes, sedges, and grasses such as Johnsongrass or Bermudagrass may be important. | 0.34 |
| Native Invasive: Deciduous Shrub Land | A variety of shrubs and generally small or sparse deciduous trees may be important in this successional type that was mapped on nonprairie soils. Important species may include water oak, sweetgum, southern red oak, Chinese tallow (south), baccharis, yaupon, winged elm, sugar hackberry, southern dewberry, and elbow-bush. Small pine trees may be present in young, managed plantations. | 0.80 |
| Native Invasive: Deciduous Woodland | This broadly-defined type is mapped on prairie soils and may contain sugar hackberry, cedar elm, water oak, sweetgum, winged elm, and yaupon as important species; Chinese tallow and loblolly pine may be present in the Southeast. | 11.0 |
| Native Invasive: Juniper Shrub Land | This type is mapped on prairie soils or on disturbance soils and is commonly dominated by eastern redcedar, A variety of deciduous species may also be present, including cedar elm, winged elm, sugar hack berry, sweetgum, water oak and mesquite. In the southeast, loblolly pine is often the dominant tree. | 1.3 |
| Non-Native Invasive: Chinese Tallow Forest, Woodland, or Shrub Land | More or less dense stands of Chinese tallow characterize this type, which is generally mapped over prairie soils. Other component species may include baccharis, sweetgum, water oak, blackgum, loblolly pine, and willow oak. | 149.0 |
| Open Water | Most open water consists of reservoirs, bays, large ponds, canals, and the Gulf of Mexico, although larger rivers are also mapped as open water. | 6.3 |
| Pine Plantation > 3 meters tall | Dense stands of loblolly or mixed loblolly and shortleaf pine characterize this type that is mapped over moist soils where natural pine stands are not expected to occur. Important components may include sweetgum, water oak, blackgum, southern red oak, post oak, and white oak. | 54.0 |
| Pine Plantation 1 to 3 meters tall | Young, planted loblolly pine stands are most common within this type, which is mapped over moist soils where natural pine stands are not expected to occur. Other species such as sweetgum, water oak, winged elm, yaupon, and southern dewberry may also be components. | 6.2 |
| Pineywoods: Bottomland Bald Cypress Swamp | Baldcypress may form nearly pure stands within this mapped type. Other important species may include water tupelo, green ash, overcup oak, willow oak, water elm, common buttonbush, or water hickory. | 0.6 |
| Pineywoods: Bottomland Seasonally Flooded Hardwood Forest | Willow oak, overcup oak (east), sweetgum, green ash, sugar hackberry, cedar elm, swamp post oak, and American elm may be important in this mapped type. Some wetter areas with water elm and baldcypress also occur, and American hornbeam is a common understory species. | 0.7 |

| Common Name | Description | Alternative 3A (acres) |
|---|---|---|
| Pineywoods: Bottomland Temporarily Flooded Hardwood Forest | Deciduous trees such as sweetgum, water oak, sugar hackberry, green ash, willow oak, blackgum, sycamore, black willow, and American elm may be important in this mapped type. American hornbeam, possumhaw and winged elm are common understory species. | 9.4 |
| Pineywoods: Disturbance or Tame Grassland | This mapped type includes many areas dominated by introduced species such as Bermudagrass, Bahia grass, and Johnsongrass. Important components may also include little bluestem, broomsedge bluestem, and hog croton, as well as shrubs such as yaupon and southern dewberry and sparse trees such as post oak and loblolly pine. | 2.9 |
| Pineywoods: Dry Upland Hardwood Forest | This mapped type includes many areas dominated by introduced species such as Bermudagrass, Bahia grass, and Johnsongrass. Important components may also include little bluestem, broomsedge bluestem, and hog croton, as well as shrubs such as yaupon and southern dewberry and sparse trees such as post oak and loblolly pine. | 16.0 |
| Pineywoods: Longleaf or Loblolly Pine/Hardwood Flatwoods or Plantation | Loblolly pine managed forests with a hardwood component characterize this type, but more natural longleaf stands may occur in the south, and slash pine managed forests also occur mainly in the south. Sweetgum, blackgum, water oak, willow oak, and swamp chestnut oak are common canopy trees. | 43.0 |
| Pineywoods: Longleaf or Loblolly Pine** Flatwoods or Plantation | Loblolly pine plantations predominate within this mapped type. Relatively natural longleaf pine stands may occur in the south, and slash pine plantations may also occur. Deciduous trees such as laurel oak, willow oak, water oak, sweetgum, swamp chestnut oak, and blackgum may also be important. | 82.0 |
| Pineywoods: Pine/Hardwood Forest or Plantation | Managed loblolly pine forests are most common within this mapped type, and hardwoods such as sweetgum, water oak, post oak, southern red oak, and cedar elm are common co-dominant species. Shortleaf pine is also a common component and longleaf pine may dominate some areas within its range (southeast). | 1.4 |
| Pineywoods: Pine Forest or Plantation | Managed loblolly pine plantations and forests predominate within this mapped type, and species such as sweetgum, southern red oak, water oak, and post oak are common components. Shortleaf pine is also common, especially to the north or on drier sties, and longleaf pine may be dominant in limited areas within the range of this species (southeast). | 73.0 |
| Pineywoods: Sandhill Oak Woodland | Blackjack oak, post oak, bluejack oak, sand post oak, southern red oak, and sweetgum may be among the dominant trees in this ridge and hilltop type. Loblolly pine, shortleaf pine, and longleaf pine (south) may be components. | 0.8 |
| Pineywoods: Sandhill Pine Woodland | Shortleaf pine, loblolly pine, or longleaf pine (south) may dominate this ridge or hilltop type, and hardwoods such as post oak, blackjack oak, bluejack oak, southern red oak, sand post oak, and sweetgum are often components. | 1.2 |
| Pineywoods: Upland Hardwood Forest | Hardwoods such as sweetgum, post oak, southern red oak, and water oak may be dominant within this mapped type, and loblolly pine or shortleaf pine are common components. Slightly wetter sites may contain species such as white oak and willow oak as important overstory trees. | 76.0 |
| Pineywoods: Wet Hardwood Flatwoods** | Species such as willow oak, sweetgum, laurel oak, water oak, swamp chestnut oak, and overcup oak may be important in these seasonally or temporarily flooded wetlands. Loblolly pine or longleaf pine (south) may also be present. Locally, Chinese tallow may dominate some areas in the south, and dwarf palmetto may form a dense understory in some stands. | 13.0 |
| Swamp | | 4.0 |

| Common Name | Description | Alternative 3A (acres) |
|---|---|---|
| Urban Low Intensity | This type includes areas that are built-up but not entirely covered by impervious cover, and includes most of the non-industrial areas within cities and towns. | 0.8 |

**Changed to match rest*

***Changed these words to match TPWD reference*

The Habitat Evaluation Procedure was developed in January 2012 to quantify the Alternative 3A ROW ecological value, the proposed 3,000-acre mitigation area and the wildlife habitat available (**Appendix O**) (CESI 2012). Based on the HEP conducted, removing existing vegetative and aquatic habitat within the Alternative 3A ROW would decrease the area's habitat value when compared to the No Action Alternative. The total average annual habitat units (AAHUs) were calculated to be 384.45 for the No Action Alternative and 190.96 for Alternative 3A. After constructing and implementing Alternative 3A, the net loss quantified as AAHUs would be 193.51. **Table 4-14** provides the AAHUs by vegetative and land use cover for Alternative 3A and the No Action Alternative (CESI 2012; **Appendix O**).

**Table 4-14:
Average Annual Habitat Units (AAHUs)
by Cover Type for Alternative 3A and No Action**

| Vegetation and Land Use/Land Cover[1] | Description | Alternative 3A AAHU | No Action AAHU |
|---|---|---|---|
| Grasslands | Grasslands are represented by improved Bermuda grass (Cynodon dactylon) pastures that have typically followed from forest clearing. Common forbs include nettles (Solanum sp.), yankeeweed (Eupatorium compostifolium), corn salad, and goldenrod. | 159.51 | 76.02 |
| Agricultural Fields (Cultivated Crops) | Areas actively used for the production of agricultural goods including grain and forage crops. This class also includes all land being actively tilled. | 8.35 | 106.26 |
| Upland Woodlands (Forest) | Areas dominated by trees generally greater than five meters tall and greater than 20 percent of total vegetation cover. This area mostly includes deciduous hardwood forests and some mixed pine-hardwood forests. | 10.64 | 96.69 |
| Evergreen Forest (Uplands) | Areas dominated by juniper shrubland, longleaf or loblolly pine/hardwood flatwoods or plantation forest | 10.24 | 93.06 |

| Vegetation and Land Use/Land Cover[1] | Description | Alternative 3A AAHU | No Action AAHU |
|---|---|---|---|
| Bottomland Hardwood Forest (Deciduous Forested Wetlands) | Bottomland hardwood forest typically associated with floodplains such that the dominant trees include willow oak, overcup oak, American elm (*Ulmus americana*), sweet gum (*Liquidambar styraciflua*), sugar hackberry (*Celtis laevigata*), and water oak (*Q. nigra). *Dominant plants in the shrub strata are often small trees, such as those listed above, and include water tupelo (*Nyssa aquatica*), deciduous holly (*Ilex decidua*), and American beautyberry (*Callicarpa americana*). Common vines in the bottomland hardwood forest include green briar (*Smilax* spp.), poison ivy (*Toxicodendron radicans*), trumpet creeper (*Campsis radicans*), and Japanese honeysuckle (*Lonicera japonica*), while common herbaceous plants include lizard's tail, sedges, goldenrod (*Solidago* spp.), and smartweed. | 1.04 | 9.45 |
| Riverine | Emergent, floating, and submergent aquatic vegetation is noticeably absent from the Gillen Bayou. Vegetation overhanging a stream channel typically includes herbs and grasses such as sedges, smartweed, and Indian sea-oats (*Chasmanthium latifolia*). Tree and shrub species include planer-tree (*Planera aquatica),* water oak, swamp privet (*Forestiera acuminata*), and water tupelo (*Nyssa aquatica*). | 0.89 | 0.28 |
| Woody and Emergent Herbaceous Wetlands | Areas dominated by wetland or riparian plants, including emergent herbaceous vegetation. Herbaceous wetlands dominated by wetland obligates such as rushes, sedges, smartweed, and lizard's tail (Saururus cernuus). Common forbs include goldenrod and morning glory (Ipomoea sp.). Native grasses such as switch grass (Panicum virgatum) and bluestems (Andropogon sp.) are common. | 0.22 | 2.04 |
| Lacustrine | Open water sites with less than 5 percent of the area consisting of emergent vegetation with shrub and tree cover also less than 5 percent | 0.07 | 0.66 |
| **Total AAHUs** | | **190.96** | **384.45** |

*Source: CESI 2012. [1]Vegetation and aquatic cover types evaluated in the HEP analysis were determined using data from the TPWD's Ecological Systems Classifications of Texas project and not the NLCD 2006*

The primary impact to vegetation resulting from site preparation and constructing the proposed pumping facility, pipeline and canal would be removing vegetation along Alternative 3A. All vegetation within the project ROW would be cleared, resulting in direct impacts to approximately 1,050 acres of vegetative resources, potential wildlife habitat (terrestrial wetlands, woodlands, pasturelands) or agricultural fields containing row crops.

After construction, habitat within the Alternative 3A ROW would include maintained grassland and riverine habitat types (CESI 2012). Various mammal species and predatory bird species would benefit from the edge habitat created by the maintained grassland. The riverine habitat would provide foraging habitat for wading birds and a fresh water source for numerous bird, mammal, aquatic and semi-aquatic species.

#### 4.6.1.4 Alternative 4

The land use/land cover data compiled from the National Land Cover Database is summarized in **Chapter 3.1** and **Table 3-23** (**Appendix R**). Within the Alternative 4 ROW there are eight land cover types that also include vegetation types that can be found in these areas. They are Cultivated Crops, Deciduous Forest, Developed Open Space, Evergreen Forest, Herbaceous Grassland, Hay Pasture, Shrub Scrub and Woody Wetlands.

The dominant vegetative type is Hay Pasture, with 55 acres or 53 percent of land use and vegetative type within the 300-foot ROW areas of Alternative 4 ROW, the next dominant type is Cultivated Crops with 33 acres or 32 percent.

Vegetation and land use/land cover types identified for the 889 acres within the 300-foot ROW of Alternative 4 are summarized in **Table 3-23** (see **Appendix R**). In addition to descriptions of land cover in the area of the project, **Table 3-23** also provides the acres and percent of each land use/land cover type found within the Alternative 4 ROW. A brief description of the vegetation communities observed within the Alternative 4 ROW is presented by **Table 4-13**.

#### 4.6.1.5 Alternative 6

The land use/land cover data compiled from the National Land Cover Database is summarized in **Chapter 3.1** and **Table 3-24** (**Appendix R**). Within the Alternative 6 ROW there are ten land cover types that also include vegetation types that can be found in these areas. They are Cultivated Crops, Low, Medium and Open Space Development, Herbaceous Grassland, Mixed Forest, Open Water, Hay Pasture, Shrub Scrub and Woody Wetlands.

The dominant vegetative type is Hay Pasture, with 52 acres or 43 percent of land use and vegetative type within the 300-foot ROW areas of Alternative 6 ROW, the next dominant type is Woody Wetlands with 44 acres or 36 percent.

Vegetation and land use/land cover types identified for the approximate 700 acres within the 300-foot ROW of Alternative 6 are summarized in **Table 3-24**. In addition to descriptions of land cover in the area of the project. **Table 3-24** also provides the acres and percent of each land use/land cover type found within the Alternative 6 ROW. A brief description of the vegetation communities observed within the footprint of the proposed action alternatives is presented below.

#### 4.6.1.6 Reduction and Mitigation of Potential Impacts

For unavoidable impacts to the approximately 203 acres of aquatic resources identified within the Alternative 3A ROW, the Corps would require compensatory mitigation to replace the ecological functions and services provided by these aquatic resources. An approximate 3,000-acre land parcel has been identified for compensatory mitigation using preservation (see **Chapter 6**). The Applicant's proposed mitigation property is adjacent to the Trinity River and surrounds the Alternative 3A ROW's northeastern portion near the CRPS. The Applicant's proposed mitigation property contains two unique topographical features: Capers Ridge and Gillen Bayou. Capers Ridge is a high ground isthmus which protrudes into Trinity River's floodplain and is approximately 75 feet higher in elevation than the surrounding floodplain. Gillen Bayou is a perennial water body which flows to the east through the southeastern portion of the Applicant's proposed mitigation property.

The habitats located on the Applicant's proposed mitigation property include deciduous and mixed hardwood forested wetlands, bottomland hardwood forests, emergent wetlands, deciduous and evergreen forested uplands, maintained grassland and fallow pastureland. The Applicant acquired the proposed mitigation property in 2010 to provide compensation for unavoidable impacts to aquatic resources through preservation. The majority of the Applicant's proposed mitigation property is forested. An area in the site's southeastern portion was cleared and has been used as pasture and grazing lands for several decades. Grazing activities have ceased since the Applicant acquired the property. The pastureland is currently fallow and undergoing succession towards scrub-shrub habitat. The previous landowner's activities have altered the landscape for portions of the Applicant's proposed mitigation property including clearing the Trinity River floodplain (pastureland along Gillen Bayou), drainage improvements, timber harvesting activities, hunting, oil and gas exploration and cattle grazing. Before the Applicant purchased the land, the property was subject to threat from imminent residential land development and clearing timber resources. Compensatory mitigation by preserving the Applicant's proposed mitigation property would remove the threat from land development and timber activities in perpetuity.

The HEP analysis concluded the existing vegetative and aquatic habitat within the Applicant 3A mitigation property was similar in habitat value when compared to the No Action Alternative. Based on the HEP analysis, the proposed mitigation property AAHUs were calculated to be 1,413.64 for the No Action Alternative scenario and 1,466.93 for the with-project scenario (Alternative 3A), resulting in a 53.29 net gain in AAHUs (**Table 4-13**).

**Table 4-13:**
**Average Annual Habitat Units by Cover Type within the Proposed Mitigation Property**

| Cover Types within the Proposed Mitigation Property[1] | With Project AAHUs | No Action AAHUs |
|---|---|---|
| Deciduous Forest (Uplands) | 283.45 | 284.64 |
| Deciduous Forest (Wetlands) | 470.43 | 360.15 |
| Evergreen Forest (Uplands) | 690.84 | 691.60 |
| Grasslands | 12.69 | 12.78 |
| Herbaceous Wetlands | 9.52 | 64.47 |
| **Total AAHUs** | **1,466.93** | **1,413.64** |

*Source: CESI 2012.*

[1]*Vegetation and aquatic cover types evaluated in the HEP analysis were determined using data from the TPWD's Ecological Systems Classifications of Texas project and not the NLCD data (2006).*

## 4.6.2 Terrestrial Wildlife

The terrestrial wildlife area of direct influence for Alternatives 3A includes the location for the Alternative 3A ROW. Construction impacts would be roads, pipeline, canal with access roads and fencing, pump and discharge stations, sedimentation basin, maintenance facility and utility lines. Areas most affected would be along the banks of the lower Trinity River, at the CRPS, along Luce Bayou at the discharge location at Lake Houston, and within approximately 5 acres of the Cedar Bayou watershed (Parcel 50).

The terrestrial wildlife area of direct influence for Alternatives 4 and 6 includes the potential location for the Alternative 4 and 6 ROW. Construction impacts would be roads, pipeline, pump and discharge stations, sedimentation basin, maintenance facility and utility lines. Areas most affected would be along the lower Trinity River, at the proposed CRPS, along the discharge location at Lake Houston, and within the Cedar Bayou watershed, especially in areas with riparian ecosystems. Habitat important to terrestrial wildlife include the riparian areas along Cedar Bayou, Luce Bayou, and the lower Trinity River and especially in floodplains, and Lake Houston. Riparian vegetation is an important component of the aquatic faunal habitat and these effects include (a) provision of fish cover (b) provision of streambank stability (c) regulation of stream temperatures (d) input of nutrients to the system and (e) direct input of invertebrates as fish food. Riparian areas provide critical wildlife habitat in many landscape settings and provides support for many wildlife requirements. Intact riparian vegetation areas are valuable and provide significant ecosystem benefit, although fragmented habitat in areas where otherwise not present, function as valuable habitat to increasingly stressed wildlife.

The construction impacts on wildlife associated with the proposed project can be divided into short-term effects resulting from physical disturbance during construction and long-term effects resulting from habitat modification and change to riparian vegetation. The net effect on local wildlife from short-term construction effects may be relatively minor. A general discussion about the construction and facility operation impacts on wildlife follows.

In general, the greatest potential impact to wildlife would result primarily from habitat loss, particularly woodland habitat, riparian, and fragmenting habitat. Woodland habitats are relatively static environments requiring a greater regenerative time compared to pastureland, cropland, grassland or emergent wetlands. The ROW would be cleared and either a canal or pipeline would be constructed. These facilitlies would be long linear surface features that are fenced to protect the public source of drinking water in accordance with EPA and Department of Homeland Security (DHS) requirements. Alternatives 4 and 6 are located in more densely populated areas of Liberty and Harris Counties, and large-scale fencing that meets specific security standards would likely be necessary. These security fences would pose a permanent, long-term adverse effect to the migration and movement of wildlife.

During construction, clearing for the pump station, pipeline and canal ROWs may impact/eliminate animals of lesser mobility and size and they may suffer habitat loss. The noise and physical activity of work crews and machinery may temporarily disturb wildlife intolerant to human disturbances. Impacts to mobile, earthbound species, such as small mammals, amphibians and reptiles, would be typically minor and temporary, since the wildlife can leave the construction area. Nests and burrows of small wildlife and others could be lost during clearing for construction activities. Clearing forested areas could leave some species temporarily deprived of cover and subjected to increased natural predation. Wildlife in the immediate area would experience a loss of browse or forage habitat due to clearing woodland and brushland within the project ROW. However, the prevalence of similar habitats in adjacent areas would minimize the effects from this loss. Herbaceous vegetation regrowth in the ROW following construction would benefit species that forage and live in open habitats.

The increased noise and activity levels during construction and routine maintenance may potentially disturb breeding or other activities of species inhabiting the areas adjacent to the ROW. A noise study conducted for the proposed pump station site showed wildlife may be affected by noise levels that would occur during the construction period. According to the noise study, assuming the pumps would generate a constant noise, wildlife beyond 500 feet would not be impacted by noise created from operating the pump station, and most wildlife would not likely be affected beyond 100 feet by the relatively small increase in background noise. Other construction impacts to wildlife would be dust and gaseous emissions from construction equipment. Periodically mowing the ROW, while producing temporary negative impacts to wildlife, improves the habitat for ecotonal or edge species due to the increased production of perennial forbs and grasses.

#### 4.6.2.1 Mammals

Based on a study conducted by Blair (1950), NLCD data (2006), site visits and aerial photography, the regional ecosystem (Austroriparian Biotic Province) was reviewed for the common mammals which would likely inhabit the proposed project area. The common mammal species that occur within the proposed project area are discussed in **Chapter 3.7.11**.

##### 4.6.2.1.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur, and there would be no impacts to mammal species inhabiting the existing area or preferred habitats.

##### 4.6.2.1.2 Alternative 3A

Mammalian wildlife would lose approximately 1,105 acres (including pump station and maintenance facility) of potential habitat for Alternative 3A. The loss of wooded areas would affect species such as foxes, bats, deer, opossums and squirrels. The loss of prairie grassland would affect rodents such as mice, rats and rabbits. The loss of underground habitat would affect species such as moles and shrews. Fossorial species found within the ROW would likely be eliminated during construction. Mammalian species that prefer forested areas and occur in the ROW's forested portions would be forced to adjust individual home ranges since the ROW would be cleared. Mammals preferring open areas or edge habitat, such as rabbits, would likely use the ROW after construction. Wildlife dependent on riparian habitat in floodplains and within the Cedar Bayou watershed would also experience a detrimental effect. The proposed canal with security fencing could create a barrier to the mobility of mammal species present in the project area, although siphons are proposed to maintain the local hydrology and allow for the movement of mammals.

##### 4.6.2.1.3 Alternative 4

Mammalian wildlife would lose approximately 985 acres (including pump station and maintenance facility) of potential habitat for Alternative 4. The loss of wooded areas would affect species such as foxes, bats, deer, opossums and squirrels. The loss of prairie grassland would affect rodents such as mice, rats and rabbits. The loss of underground habitat would affect species such as moles and shrews. Fossorial species found within the ROW would likely be eliminated during construction. Mammalian species that prefer forested areas and occur in the ROW's forested portions would be forced to adjust individual home ranges since the ROW would be cleared. Wildlife dependent on riparian habitat in floodplains and within the Cedar Bayou watershed would also experience a long-term, adverse effect. The proposed pipeline easement would be a graded, mowed, maintained, and slightly elevated above the ground surface. The easement would be surrounded by security fencing and lighting in the populated areas along the Alternative 4 ROW and these features would create a barrier to the mobility of mammal species present in the project area. It is expected that hydraulic and hydrologic studies would be performed during final design phase for the pipeline alternatives, and that drainage conveyance structures and features may be implemented that may also include wildlife crossings; however, wildlife would be adversely and permanently affected by the implementation of Alternative 4. Mammals preferring open areas or edge habitat, such as rabbits, would likely use the ROW after construction.

##### 4.6.2.1.4 Alternative 6

Mammalian wildlife would lose approximately 725 acres for Alternative 6, as a result of the proposed project. The loss of wooded areas would affect species such as foxes, bats, deer, opossums and squirrels. The loss of prairie grassland would affect rodents such as mice, rats and rabbits. The loss of underground habitat would affect species such as moles and shrews. Fossorial species found within the ROW would likely be eliminated during construction. Mammalian species that prefer forested areas and occur in the ROW's forested portions would be forced to adjust individual home ranges since the ROW would be cleared. Wildlife dependent on riparian habitat in floodplains and within the Cedar Bayou watershed would also experience a long-term, adverse effect. The proposed pipeline easement would be a graded, mowed, maintained, and slightly elevated above the ground surface. The easement would be surrounded by security fencing and lighting in the populated areas along the Alternative 6 ROW and these features would create a barrier to the mobility of mammal species present in the project area. It is expected that hydraulic and hydrologic studies would be performed during final design phase for the pipeline alternatives, and that drainage conveyance structures and features may be implemented that may also include wildlife crossings; however, wildlife would be adversely and permanently affected by the implementation of Alternative 6. Mammals preferring open areas or edge habitat, such as rabbits, would likely use the ROW after construction. Mammals preferring open areas or edge habitat, such as rabbits, would likely use the ROW after construction.

#### 4.6.2.1.5 Reduction and Mitigation of Potential Impacts

As discussed in more detail in **Chapter 6**, mitigation for habitat lost due to the proposed project includes an approximate 3,000-acre property (2,983 acres) which has been identified for compensatory mitigation. To facilitate wildlife movement, the proposed 18 siphon structures conveying water in the canal below the ground surface in concrete box culverts could be used as wildlife crossings. The surface expression for these drainage conveyance structures would be 200 feet long by 300 feet wide and would include ditches, swales or open grassy areas. These structures would not be located at pipeline, utility easements or roadway crossings and would allow safe wildlife passage across the LBITP canal. In addition, it would be expected that hydraulic and hydrologic studies would be performed during final design such that drainage conveyance structures and features for the pipeline sections of the LBITP may be implemented; these features may also include wildlife crossings; however, this would reduce but not eliminate permanent adverse effects of the LBITP.

Fencing would be placed on either side of the LBITP ROW. During preliminary planning, it was thought that six-foot-tall, 4-strand, barb-wire fences would be constructed along both sides of the LBITP easement including along the pipeline and canal for security purposes. This fence would be constructed using barb wire except at roadway crossings where chain-linked fences would be constructed. Barb-wire fences are not anticipated to pose a travel barrier for most species, as the strands may be designed to facilitate wildlife movement. However, with the heightened terrorist threat in the United States, it is important to manage security concerns associated with the LBITP water transfer to Lake Houston, a Houston metropolitan area drinking water supply source. Contamination through biological agents would be a concern in open water situations such as canals or channels. At roadway and other crossings, the raw water from the Trinity River could be contaminated and source water protection would be addressed to control threats to public safety related to source water protection requirements as implemented by the EPA. In terms of citizen safety, installation of fencing surrounding the LBITP canal and potentially along the pipeline easements would be necessary to prevent accidental, water-related injuries from occurring.

Security measures along the LBITP ROW would need to be implemented. Along the proposed Alternative 3A alignment for the canal ROW, the area is remote with limited access roads, property parcels are relatively large in extent, and are actively farmed with the result that property access is already restricted. In the vicinity of Alternative 3A, it is possible that security and fencing requirements coordinated with the EPA and DHS, as needed, would also be favorable to wildlife movement and habitat use. The proposed CRPS facilities at the Trinity River (Alternatives 3A and 4) would be surrounded by security chain-link fencing topped with 4-strand barb wire and would contain ownership information and no trespassing signage. The existing TRPS (Alternative 6) and the proposed pipeline easement would also need fencing to manage security. However, the ability for wildlife to migrate through the project area would be restricted considering the type of security fencing that may be needed to balance the need for protection of drinking water supplies.

Barb-wire fencing would not present a barrier to smaller animals such as mice or raccoons which can move underneath the lower wires. However, it could create a dangerous hazard to larger wildlife species such as deer, which can become tangled and trapped in barb-wire fencing. To minimize negative impacts to deer, all wires would be kept tight to prevent deer and other large mammals from being entangled between the top two wire strands.

### 4.6.3 Recreationally and Commercially Important Wildlife Species

The area of direct influence in Alternative 3A for recreationally and commercially important wildlife species includes the potential Alternative 3A ROW location including roads, pipeline, canal with access roads and fencing, pump and discharge stations, sedimentation basin, maintenance facility and utility lines, the proposed mitigation property and the lower Trinity River, Lake Livingston, Lake Houston, and Galveston Bay.

Based on a study conducted by Blair (1950), NLCD data (2006), site visits and aerial photography, the regional ecosystem (Austroriparian Biotic Province) was reviewed for recreationally and commercially important wildlife species likely inhabiting the proposed project area. These species are discussed in **Chapter 3**.

#### 4.6.3.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur, and there would be no impacts to the lower Trinity River, Lake Livingston, Lake Houston, or Galveston Bay. No impacts would occur to habitat areas used by recreationally or commercially important wildlife species.

#### 4.6.3.2 Alternative 3A, Alternative 4 and Alternative 6

Habitat occupied by species pursued for recreational purposes would be lost. Impacts to wildlife species due to project-related construction activities including recreationally important species were previously discussed. A change from private to public land use would occur due to the Alternatives 3A, 4 and 6 construction, operation and maintenance, but no direct impact to existing public lands would occur. Less than one percent of the undeveloped land which could be used by recreationalists who enjoy viewing or hunting wildlife, would be directly impacted by the proposed project in the long-term.

#### 4.6.3.3 Reduction and Mitigation of Potential Impacts

The proposed mitigation site would be deeded to the USFWS to be included in the TRNWR. The mitigation area would be made available for public recreational use, increasing the amount of public land in Liberty County. To facilitate movement of important wildlife species, the proposed 18 siphon structures conveying water in the canal below the ground surface in concrete box culverts could be used as wildlife crossings. The surface expression for these drainage conveyance structures would be 200 feet long by 300 feet wide and would include ditches, swales or open grassy areas. These structures would not be located at pipeline, utility easements or roadway crossings and would allow safe wildlife passage across the LBITP canal. In addition, it would be expected that hydraulic and hydrologic studies would be performed during final design such that drainage conveyance structures and features for the pipeline sections of the LBITP may be implemented; these features may also include wildlife crossings; however, this would reduce but not eliminate permanent adverse effects of the LBITP.

## 4.6.4 Amphibians and Reptiles

The area directly influenced by Alternative 3A for reptiles and amphibians includes the potential location for the Alternative 3A ROW including roads, pipeline, canal with access roads and fencing, pump and discharge stations, sedimentation basin, maintenance facility and utility lines plus the lower Trinity River at the permitted Capers Ridge diversion point to approximately 2,000 feet downstream, the approximate 3,000-acre proposed mitigation property, and the discharge location at Luce Bayou near Lake Houston.

Based on a study conducted by Blair (1950), NLCD data (2006), site visits and aerial photography, the regional ecosystem (Austroriparian Biotic Province) was reviewed for the common reptiles and amphibians likely inhabiting the proposed project area. The common amphibian and reptile species found within the proposed project area are discussed in **Chapter 3**.

### 4.6.4.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur, and there would be no impacts to amphibian or reptile species inhabiting the existing area or the preferred habitats.

### 4.6.4.2 Alternative 3A

Reptile and amphibian wildlife would lose potential habitat such as wooded areas due to construction, operation and maintenance activities. Typically, reptiles inhabiting the ROW of large construction projects would be eliminated. Surrounding areas have similar habitat and vegetation which can be inhabited by species mobile enough to leave the construction area. For herptile species that prefer woody habitats and occur in the Alternative 3A vicinity, home ranges would likely be adjusted due to clearing the ROW. The proposed canal could cause a barrier to more land-based reptiles such as box turtles; however, most reptiles and amphibians would be able to traverse the canal to search for foraging and nesting areas. After the canal is in operation, the open water could provide habitat for some herptile species. Removing vegetative areas, including wooded areas, could potentially result in a direct short-term impact to reptile and amphibian species.

### 4.6.4.3 Alternative 4

Reptile and amphibian wildlife would lose potential habitat such as wooded areas due to construction, operation and maintenance activities. Typically, reptiles inhabiting the ROW of large construction projects would be eliminated. Surrounding areas have similar habitat and vegetation which can be inhabited by species mobile enough to leave the construction area. For herptile species that prefer woody habitats and occur in the Alternative 4 vicinity, home ranges would likely be adjusted due to clearing the ROW. Removing vegetative areas, including wooded areas, could potentially result in a direct short-term impact to reptile and amphibian species.

### 4.6.4.4 Alternative 6

Reptile and amphibian wildlife would lose potential habitat such as wooded areas due to construction, operation and maintenance activities. Typically, reptiles inhabiting the ROW of large construction projects would be eliminated. Surrounding areas have similar habitat and vegetation which can be inhabited by species mobile enough to leave the construction area. For herptile species that prefer woody habitats and occur in the Alternative 6 vicinity, home ranges would likely be adjusted due to clearing the ROW. Removing vegetative areas, including wooded areas, could potentially result in a direct short-term impact to reptile and amphibian species.

### 4.6.4.5 Reduction and Mitigation of Potential Impacts

Mitigation for habitat lost due to the proposed project includes an approximate 3,000-acre (2,983 acre) land parcel which has been identified for compensatory mitigation.

## 4.6.5 Birds

The area directly influenced by Alternative 3A for birds includes Alternative 3A ROW's potential location including roads, pipeline, canal with access roads and fencing, pump and discharge stations, sedimentation basin, maintenance facility and utility lines plus the lower Trinity River, Lake Livingston, Lake Houston, and Galveston Bay.

Based on a study conducted by Blair (1950), NLCD data (2006), site visits and aerial photography, the regional ecosystem (Austroriparian Biotic Province) was reviewed for the common bird species likely inhabiting the proposed project area. The common bird species occurring within the proposed project area are discussed in **Chapter 3.7.14**.

### 4.6.5.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur and there would be no impacts to the lower Trinity River, Lake Livingston, Lake Houston, or Galveston Bay. No impacts would occur to bird species that currently inhabit the existing habitats and the vegetative islands associated with Stroesser Farms, Inc. reservoir.

### 4.6.5.2 Alternative 3A

Avian wildlife would permanently lose approximately 1,050 acres of potential habitat due to the proposed project. Aquatic area loss would affect herons, coots, geese, ducks and other birds which forage or inhabit aquatic areas. Upland woodlands loss would affect species such as owls, woodpeckers and hawks. The overall loss of wooded areas and prairie grassland would affect migratory and residential bird species in general. However, surrounding areas have similar habitat and vegetation which can be used by avian wildlife.

Impacts from proposed project construction on birds are considered to be beneficial and adverse. A potential beneficial effect on avian species from the proposed project would be providing edge habitats adjacent to the proposed ROW. This edge habitat would benefit species such as the Blue Jay, Flycatchers, Northern Cardinal, Cooper's hawk (*Accipiter cooperii*) and Northern Mockingbird. Adverse impacts to avian species from the proposed project construction, ROW construction, and maintenance would range from habitat loss to population fragmentation. Several studies indicate forest and grassland fragmentation have negative effects on avian species which show a marked preference for large undisturbed and/or native habitat patches. Species are not randomly distributed regarding habitat patch size, and fragmentation favors edge- and small-patch-adapted species. For those species dependent on larger patches and less adapted to edge, increases in woodland or forest edge effect can increase predation, brood parasitism, invasive species introduction, and reduce mating and nesting success.

In accordance with the Migratory Bird Treaty Act to protect migratory bird species, clearing the ROW in the vicinity of reservoirs would occur outside the bird nesting season (February 15 to September 1). The TPWD considers construction activities to include, but does not limit them to, removing nests or nest structures, tree felling, vegetation clearing, trampling and maintenance. If nesting pairs of migratory birds are observed, construction activities in those areas would be rescheduled if possible to avoid impacts.

Impacts to avian species from the proposed project construction, operation, and maintenance activities range from habitat loss to fragmented populations. Several studies indicate forest and grassland fragmentation have negative effects on some avian species that show a marked preference for large undisturbed and/or native habitat patches (Wilcove and Terborgh 1984; Askins, Philbrick and Sugeno 1990; Blair 1966; Blair 2001; Sauer, Hines and Fallon 2005; and, Whitcomb et al. 1981). For species dependent on larger habitat areas and less adapted to edge or fragmented habitat, increases in woodland or forest edge effect can increase predation, brood parasitism, invasive species introduction, and reduce mating and nesting success.

A potential beneficial effect on avian species from the proposed project would be providing edge habitats adjacent to the proposed ROW. This edge habitat would benefit species such as the Blue Jay, Flycatchers, Northern Cardinal, Cooper's hawk (*Accipiter cooperii*) and Northern Mockingbird. Adverse impacts to avian species from the proposed project construction, ROW construction, and maintenance would range from habitat loss to population fragmentation. Several studies indicate forest and grassland fragmentation have negative effects on avian species which show a marked preference for large undisturbed and/or native habitat patches. Species are not randomly distributed regarding habitat patch size, and fragmentation favors edge- and small-patch-adapted species. For those species dependent on larger patches and less adapted to edge, increases in woodland or forest edge effect can increase predation, brood parasitism, invasive species introduction, and reduce mating and nesting success.

### 4.6.5.3 Alternative 4

Avian wildlife would lose approximately 985 acres (including pump station and maintenance facility) of potential habitat for Alternative 4. Aquatic area loss would affect herons, coots, geese, ducks and other birds which forage or inhabit aquatic areas. Upland woodlands loss would affect species such as owls, woodpeckers and hawks. The overall loss of wooded areas and prairie grassland would affect migratory and residential bird species in general. However, surrounding areas have similar habitat and vegetation which can be used by avian wildlife.

Impacts from proposed project construction on birds are considered to be beneficial and adverse. A potential beneficial effect on avian species from the proposed project would be providing edge habitats adjacent to the proposed ROW. This edge habitat would benefit species such as the Blue Jay, Flycatchers, Northern Cardinal, Cooper's hawk (*Accipiter cooperii*) and Northern Mockingbird. Adverse impacts to avian species from the proposed project construction, ROW construction, and maintenance would range from habitat loss to population fragmentation.

Several studies indicate forest and grassland fragmentation have negative effects on avian species which show a marked preference for large undisturbed and/or native habitat patches. Species are not randomly distributed regarding habitat patch size, and fragmentation favors edge- and small-patch-adapted species. For those species dependent on larger patches and less adapted to edge, increases in woodland or forest edge effect can increase predation, brood parasitism, invasive species introduction, and reduce mating and nesting success.

### 4.6.5.4 Alternative 6

Avian wildlife would lose approximately 725 acres for Alternative 6, as a result of the proposed project. Aquatic area loss would affect herons, coots, geese, ducks and other birds which forage or inhabit aquatic areas. Upland woodlands loss would affect species such as owls, woodpeckers and hawks. The overall loss of wooded areas and prairie grassland would affect migratory and residential bird species in general. However, surrounding areas have similar habitat and vegetation which can be used by avian wildlife.

Impacts from proposed project construction on birds are considered to be beneficial and adverse. A potential beneficial effect on avian species from the proposed project would be providing edge habitats adjacent to the proposed ROW. This edge habitat would benefit species such as the Blue Jay, Flycatchers, Northern Cardinal, Cooper's hawk (*Accipiter cooperii*) and Northern Mockingbird. Adverse impacts to avian species from the proposed project construction, ROW construction, and maintenance would range from habitat loss to population fragmentation. Several studies indicate forest and grassland fragmentation have negative effects on avian species which show a marked preference for large undisturbed and/or native habitat patches. Species are not randomly distributed regarding habitat patch size, and fragmentation favors edge- and small-patch-adapted species. For those species dependent on larger patches and less adapted to edge, increases in woodland or forest edge effect can increase predation, brood parasitism, invasive species introduction, and reduce mating and nesting success.

#### 4.6.5.5 Reduction and Mitigation of Potential Impacts

In accordance with the Migratory Bird Treaty Act to protect migratory bird species, clearing the ROW in the vicinity of reservoirs would occur outside the bird nesting season (February 15 to September 1). The TPWD considers construction activities to include, but does not limit them to, removing nests or nest structures, tree felling, vegetation clearing, trampling and maintenance. If nesting pairs of migratory birds are observed, construction activities in those areas would be rescheduled if possible to avoid impacts.

### 4.6.6 Aquatic Species

The area of direct influence for Alternative 3A and Alternative 4 for aquatic species includes the proposed location of the CRPS and the Luce Bayou discharge structure and approximately 2,000 feet downstream of each as well as the aquatic environment of the upper and lower Trinity River, upper and lower San Jacinto River, Lake Livingston, Lake Houston, and Galveston Bay.

The area of direct influence for Alternative 6 for aquatic species includes the proposed location of the Trinity River Pump Station and the Luce Bayou discharge structure and approximately 2,000 feet downstream of each as well as the aquatic environment of the upper and lower Trinity River, upper and lower San Jacinto River, Lake Livingston, Lake Houston, and Galveston Bay.

#### 4.6.6.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur and there would be no impacts to fish or mussel species that inhabit the existing area, their preferred habitats, or the to the lower Trinity River, Lake Livingston, Lake Houston, or Galveston Bay. No long-term, direct effects would be expected to occur.

#### 4.6.6.2 Alternative 3A, Alternative 4, and Alternative 6

A freshwater mussel survey was conducted in January 2012 in the Trinity River at the proposed Capers Ridge Pump Station and in the East Fork of the San Jacinto River at the proposed Lake Houston discharge structure to characterize the habitats and mussels, including abundance and species, occurring in these waters (AECOM 2012). For this survey, TPWD issued a collection permit to allow for mussels to be identified in the lower Trinity River and Luce Bayou at Lake Houston. The characterization methods for habitat and mussel species were similar for both the Trinity River and Lake Houston locations with the exception of the higher frequency of wader-based survey techniques in the Lake Houston discharge area due to the lower water levels. Transects approximately 300 feet in length and 25 feet apart were established and live mussels and mussel shells encountered along the transects were collected for identification. Live mussels were returned to the area from which they were obtained. Habitat characterization along the established transects included a general description of the submerged aquatic vegetation (SAV), SAV percent cover, and dominant substrate type.

Risk analyses were conducted for Alternative 3A in which water quality data from 11 stations were examined (three stations in the San Jacinto River watershed above Lake Houston, five stations in the Lower Trinity River watershed, and three stations in Lake Houston) for factors that would most likely impact a successful establishment of zebra and quagga mussel populations (McMahon 2012). These factors include summer surface water temperatures, calcium concentrations, surface water pH levels, and surface water dissolved oxygen (DO) concentrations.

Impacts to fish and freshwater mussels could occur from construction within the watershed, such as dredging, trenching, or soil and fill runoff. Effects from such activities include excessive sedimentation, changes in water flow and speed, and exposure from clearing out debris where mussels might take shelter. The construction of the proposed pumping station and outflow would require construction activities within the Trinity River and the backwaters of Lake Houston near Luce Bayou. Freshwater mussels and benthic species located at these locations would likely be removed. Following construction and once water is returned, benthic organism and mussels would likely re-establish in the area. Potential direct impacts to fish and freshwater mussel species as a result of construction activities would not be permanent and would be short-term in duration.

Fishing is an important recreational activity on the Trinity River and Lake Houston although neither of the waterbodies is commercially fished. As described in **Chapter 3.7**, numerous species of fish that occur within the Trinity River and Lake Houston are desirable to anglers. These fish are generally abundant in both waterbodies. The proposed pump station would impinge some game fish on the screens and entrain fish eggs in the transfer system. The minor loss of game species would not have a measurable impact on recreational fish species along the Trinity River. The existing TRPS downriver of the proposed CRPS has not had a measurable impact on recreational fish species.

The outfall discharge at Luce Bayou near the confluence with Lake Houston would likely benefit recreational fish species in the area. Predictive models have shown that DO may slightly increase as a result of the project. The water transfer would also help water levels during drought times. Since a small area (0.30 acre) would be dewatered during construction, fish occupying that area would likely be eliminated. After construction, the same amount of surface water area would be present, allowing recreational species to re-inhabit the area. Construction-related activities could potentially result in short-term direct impacts to recreationally and commercially important fish species while the area is dewatered for construction.

Based on the 2012 mussel survey conducted at the Trinity River and Lake Houston, no Federal- or State-listed threatened and/or endangered, rare, invasive, or potential candidate species of freshwater mussels were identified (AECOM 2012; McMahon 2012). During this survey, one juvenile giant floater mussel, several giant floater mussels and two southern maple leaf mussel shells were collected from the Trinity River. Similar to earlier reports by Howells (2009), current data and survey results do not indicate notable freshwater mussel populations in the lower Trinity River downstream of Lake Livingston or at the discharge location of Alternative 3A. Habitat constraints for freshwater mussels including an unstable environment, shifting sands and silts, decaying vegetative cover (Lake Houston), collapsing or unstable river or stream banks, extreme water level fluctuations or temperature fluctuations resulting from long periods of exposure, and other anthropogenic influences create conditions that are undesirable for freshwater mussels. The conclusion based on the survey conducted would be that the aquatic habitat in the vicinity of the proposed action alternatives is unlikely to support large, diverse or rare unionid populations although it is possible that areas of the lower Trinity River may contain small pockets of micro-habitat that could support limited numbers of freshwater mussels (Howells 2009).

According to studies conducted, mussels that inhabit the lower Trinity River and Lake Houston are not known to include rare unionid species currently being considered for State or Federal listing (Howells 2009). According to these investigations, Alternative 3A would not be expected to have direct impacts on mussel species that are candidates for State or Federal listing or to pose major threat to existing unionid populations.

Impacts to freshwater mussels are also known to occur from the introduction of exotic bivalves, such as Asian clams or zebra mussels. In many instances, exotic species can outcompete and outpopulate native mussel species in a short period of time. Many exotic species are known to attach to pipes and equipment making them inoperable until the species are removed. Asian clams have already been introduced in this area in the past and zebra mussels have been discovered in Lake Lavon in the upper Trinity River drainage, making it possible for them to reach the lower Trinity River area. Successful measures to control zebra mussels are limited to physical and chemical treatments. However, many of these treatments would be prohibited for use in drinking water supplies such as Lake Houston.

The proposed action alternatives could potentially introduce habitats that may be conducive to inhabitation by zebra mussels. Operation of the canal would likely create additional habitat for benthic, mussel, and nekton species. Risk analyses conducted for the proposed project stated that if " zebra mussels become established in Lake Livingston, mussel larvae carried downstream in the lower Trinity River could be transported to Lake Houston via the proposed Alternative 3A from the Trinity River to Lake

Houston" (McMahon 2012). Should a zebra mussel infestation occur in Lake Houston, only populations of low density would occur as the larvae would be carried further downstream into Trinity Bay. In addition, based on the water quality data reviewed in the analyses, "…the waterways and reservoirs on the watersheds of the San Jacinto and lower Trinity Rivers encompassed by the examined stations would be highly resistant to quagga mussel invasion due to their summer surface water temperatures being elevated above its incipient upper thermal limit of 28°C" (McMahon 2012). However, zebra mussels have a high incipient thermal limit (32°C) and could therefore establish a population in the waterways and waterbodies of the San Jacinto and lower Trinity River watersheds.

It is unlikely that major, long term, widespread or permanent direct impacts to fish or freshwater mussels would occur as a result of construction, operation, or maintenance associated with Alternatives 3A, 4 or 6 with the exception of the potential transfer of the invasive zebra mussel species from the lower Trinity to the San Jacinto River watersheds.

Pumping at the CRPS could impinge larger fish on intake screens, and entrain fish eggs and mussel larvae through the transfer system. The proposed Alternative 3A would utilize a trash rack and screening that would impact aquatic species who could potentially get caught and trapped. Although there is a risk of impingement and entrainment on the pump intake screens at the Capers Ridge Pump Station, during typical pumping operations, the intake screen design would control approach velocities at the Trinity River intake structure. During normal flow conditions, the intake approach velocities would be approximately 0.4 feet/second (ft/sec). The anticipated approach velocity would be expected to reduce the effect of Alternative 3A on fish and nekton of the Trinity River. In addition, the proposed intake screens would be constructed in the banks of the channel. The location of these screens within the channel bank could also potentially reduce the risk of entrainment. The screens would be designed to allow smaller- to medium-sized organisms to pass through, which would reduce mortality on nektonic species that may be incidentally discharged into Alternative 3A conveyance channel canal.

### 4.6.6.3 Essential Fish Habitat

The area of direct influence for the proposed alternatives for essential fish habitat (EFH) includes the intake pump and discharge stations, the lower Trinity River, Lake Houston, Lake Livingston, and Galveston Bay.

#### 4.6.6.3.1 No Action

Under Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur and there would be no impacts to the lower Trinity River, Lake Livingston, Lake Houston, or Galveston Bay. No long-term, direct effects would be expected to occur.

As discussed in **Section 3.7.15.2**, Essential Fish Habitat, information from NOAA/NMFS was reviewed to determine EFH areas within the proposed action alternatives area and the Influence Area for aquatic species.

#### 4.6.6.3.2 Alternative 3A

Lake Houston is considered EFH by NMFS. However, the proposed discharge point into Luce Bayou upstream of Lake Houston would not impact tidally influenced waters and would not impact marsh or other type of nursery habitat for species listed for Lake Houston. The construction, operation and maintenance of Alternative 3A would not have long-term, permanent direct or indirect impacts on the existing EFH areas of Lake Houston.

#### 4.6.6.3.3 Alternative 4, and Alternative 6

Lake Houston is considered EFH by NMFS. The proposed discharge point into Luce Bayou upstream of Lake Houston may impact tidally influenced waters and marsh or other type of nursery habitat for species listed for Lake Houston. The construction, operation and maintenance of Alternative 4 and 6 may therefore have long-term, permanent direct or indirect impacts on the existing EFH areas Lake Houston.

#### 4.6.6.4 Reduction and Mitigation of Potential Impacts

No mitigation is required as no impacts to the Lake Houston EFH, marsh or other fish nurseries listed for Lake Houston would occur as a result of the construction, operation and maintenance of the proposed action alternatives. Information for Federal- or State-listed threatened and/or endangered, rare, invasive, or potential candidate species is provided in **Chapter 4.8**, Threatened and Endangered Species.

### 4.6.7 Vegetation

The area of direct influence for Alternatives 3A, 4, and 6 for terrestrial vegetation and wildlife includes the proposed location for LBITP ROW including roads, pipeline, access roads, drainage ditches, canal, pump and discharge stations, sedimentation basin, maintenance facility and utility lines.

#### 4.6.7.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur and there would be no direct or indirect impact or change to the existing vegetation/land cover types or to wildlife habitats within the Alternative 3A, 4, or 6 ROW.

#### 4.6.7.2 Alternative 3A

##### 4.6.7.2.1 Analysis Method

Vegetation and land cover types occurring within the Alternative 3A ROW were identified and described in by **Table 3-22** based on the National Land Cover Database of 2006 (NLCD 2006) and the results of field investigations conducted by biologists. NLCD 2006 is a 16-class land cover classification scheme for the conterminous United States that was developed at a spatial resolution of 100 feet. NLCD 2006 is based primarily on the classification of Landsat Enhanced Thematic Mapper+ (ETM+) circa 2006 satellite data. These data were used along with GIS analyses of aerial photography and the results of field investigations to initially determine the vegetation/land cover types directly affected by the construction of Alternative 3A. The analyses conducted included the quantification of the total number of acres within the Alternative 3A ROW by vegetation type (see **Table 4-13**). Since the above analyses were conducted, Phase I and Phase II of the Ecological Systems Classification and Mapping Project in support of the Texas Comprehensive Wildlife Conservation Strategy have been conducted and the results have been published (TPWD 2012 and TPWD in progress). These latest state-wide efforts at vegetative classification have been integrated into the Habitat Evaluation Procedure (HEP) conducted by USACE to address public scoping comments, the alternatives analysis presented in **Chapter 2.5 and Chapter 2.9** of this DEIS, and the vegetative type effects analyses conducted for Alternative 3A.

To evaluate the function and habitat value represented by the vegetative and use type within the Alternative 3A ROW, a Habitat Evaluation Procedure (HEP) was conducted, as directed by USACE to address public comment received in response to the Public Scoping Meeting held on Thursday, July 21, 2011 for the Luce Bayou Interbasin Transfer Project Draft Environmental Impact Statement. The generalized process for conducting a HEP study involves the following components (USFWS 1980):

- Determine the applicability of HEP and define the study area
- Delineate habitat or vegetation cover types
- Select the relevant evaluation species
- Determine each species' life requisites
- Measure habitat variables for suitability

- Determine baseline and future habitat units
- Develop compensation/mitigation plans for the proposed project

The HEP is a habitat-based evaluation methodology developed by U.S. Fish and Wildlife Service (USFWS) in 1974 for use as an analytical tool in impact assessments and project planning. HEP is used to evaluate the species and potential habitat present based on an analysis of the ecological value of an area. The approach is to quantify the value of habitat available to a selected set of wildlife species within a specified geographic area of interest. The method is designed to describe wildlife habitat values at baseline and future conditions to allow for comparisons of the relative values of different areas at the same point in time or of the same area at different points in time. Because HEP provides a quantitative method for such comparisons, it may be used to undertake assessments of current and future wildlife habitat or compensation analyses.

HEP appraises a study area by quantifying its habitat value, calculated as the product of habitat quantity and habitat quality. This value is expressed in Habitat Units (HU). Habitat quantity is simply the total area of habitat available within the study area, usually expressed in number of acres. Available habitat within the study area may be subdivided into cover types, or distinct areas with similar ecological characteristics that are adequately homogeneous. If the study area is subdivided into cover types, habitat quantities used in evaluation may be subsets of the study area. Habitat quality is expressed in terms of a Habitat Suitability Index (HSI), which is determined by comparing the ecological characteristics of the study area to the habitat characteristics that are optimum for the evaluation species. Evaluation species are representative wildlife species with known habitat requirements selected to provide the basis for assessment of habitat suitability.

HSI values are based on two components, including the habitat characteristics that provide ideal conditions for an evaluation species and the habitat characteristics existing in the study area. These characteristics are described by a set of measurable habitat variables, such as the height and percent cover of various vegetation types, the distance to water or food, the availability of perching or nesting sites, or the frequency of flooding. The set of habitat variables needed to determine HSI values are obtained from documented habitat suitability models for each evaluation species. These models describe the life requisites of each species, the relationship between the values of habitat variables, the suitability of the area to meet its life requisites, and the method to integrate these suitability relationships into an HSI value. HSI values range from zero (0.0) to one (1.0), with zero representing unsuitable conditions and 1.0 being optimal conditions.

Habitat values may be calculated for each evaluation species within its available habitat or for each cover type within the study area. Calculations based on existing ecological conditions can be used to describe baseline conditions and serve as a reference point for comparison to predicted future habitat values with or without proposed actions or mitigation measures. HEP provides a consistent means of assessing project impacts by demonstrating, in HUs gained or lost, the beneficial or adverse impacts anticipated as a result of various courses of action. HEP aids mitigation analysis by identifying which factors negatively impact habitat values in various scenarios, thus suggesting means for improving habitat or selecting mitigation lands.

#### 4.6.7.2.2 Environmental Consequences

Alternative 3A begins in central Liberty County, Texas, extends along Capers Ridge from the Trinity River intake structure and terminates in northeast Harris County, Texas near the confluence of the East Fork of the San Jacinto River and Lake Houston. Alternative 3A is approximately 140,000 linear feet or 26.5 miles in length, and would encompass approximately 1,050 acres within a 300-foot wide ROW; additionally there would be approximately 90 acres required for a pump station, and approximately 10 acres required for a maintenance facility. The existing habitat within the ROW of Alternative 3A is comprised of forested areas, terrestrial wetlands, agricultural land, grazing land, and public land (roads and public utilities).

Based on both the NLCD 2006 database and field investigations including those conducted to perform the PJD along the Alternative 3A ROW, seven terrestrial vegetation types were identified within the

Alternative 3A ROW: Upland Woodlands (Forest), Mosaic/Transitional Woodlands (Mixed Forest), agricultural fields (Row Crops), Pasturelands (Pasture and Hay), Scrub-Shrub vegetation, Wetlands and Hydric Communities (Woody and Emergent Herbaceous Wetlands), and Open Water. Based on this vegetative and land use classification scheme, the dominant vegetative type directly and permanently impacted by the construction and operation of Alternative 3A is Upland Woodlands (32 percent) within the 300-foot Alternative 3A ROW, closely followed by Agricultural Fields (28 percent). The summary of direct permanent impacts to vegetation and land cover within the Alternative 3A ROW is provided by **Table 4-15**.

**Table 4-15:**
**Vegetation and Land Use/Land Cover Data for the Alternative 3A ROW**

| Vegetation and Land Use/Land Cover | Description | Approximate Area (acres) | Percent Cover (%) |
|---|---|---|---|
| Upland Woodlands (Forest) | Areas dominated by trees generally greater than five meters tall and greater than 20 percent of total vegetation cover. This area mostly includes deciduous hardwood forests and some mixed pine-hardwood forests. | 338 | 32 |
| Mosaic/Transitional Woodlands (Mixed Forest) | Areas dominated by trees generally greater than five meters tall, and greater than 20 percent of total vegetation cover. These flat woodlands are transitional forests interspersed with small wetland communities. | 25 | 2 |
| Agricultural Fields (Cultivated Crops) | Areas actively used for the production of agricultural goods including grain and forage crops. This class also includes all land being actively tilled. | 286 | 28 |
| Pasturelands (Pasture, Hay) | Areas with 80 percent or greater herbaceous vegetation with little to no woody vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing. | 135 | 13 |
| Scrub/Shrub | Areas dominated by shrubs less than five meters tall with shrub canopy typically greater than 20 percent of total vegetation. This class includes tree shrubs, young trees, or stunted trees. | 40 | 4 |
| Wetlands and Hydric Communities (Woody and Emergent Herbaceous Wetlands) | Areas dominated by wetland or riparian plants, including herbaceous and wooded vegetation. | 200 | 19 |
| Open Water | All areas of open water, generally with less than 25 percent cover of vegetation or soil. | 26 | 2 |
| **Total** | | **1,050** | **100.00** |

*NLCD2006; Summary PJD Reports submitted to USACE (AECOM 2010)*

The TPWD's *Ecological Systems Classification of Texas Project* grew out of a recognized need to provide better land cover classification and mapping for the state in order to facilitate improved planning and management. The original satellite-based land cover map was produced by the Texas Parks and Wildlife Department in 1984 (McMahan et al. 1984). As described above, that map series was updated by more recent products, including the latest NLCD (http://landcover.usgs.gov/uslandcover.php ), the USGS GAP Analysis dataset (http://gapanalysis.nbii.gov/portal/server.pt ), and the national LandFire map (http://www.landfire.gov ). All of the recent maps resulted in 30 meter resolution datasets, appropriate for planning at regional and statewide scales of resolution. The national 'gold standard' is NLCD (developed using circa 2001 satellite data), which recognized fewer than 20 land cover types statewide. None of these efforts have produced maps that are generally useful at a county level or below. The goal of the Ecological Systems Classification of Texas Project was to produce a map with a useful spatial resolution at a 1:24,000 scale (1 inch = 2,000 feet, the same scale as a U.S. Geological Survey (USGS) 7.5-minute quadrangle map) that would also contain a sufficient number of land cover and vegetative classes (thematic resolution) to provide improved insights for planning and management at a sub-county, or large ownership, scale of resolution. The referenced map was produced by first classifying the land cover, and then using ancillary data (e.g. hydrology, environmental data, highways and cities) to model final mapped vegetation types. The first step resulted in 15 base land cover classes, whereas the second step resulted in the identification of 109 mapped vegetation types across the state of Texas. These efforts provide planning level vegetative classifications at a 30 foot resolution with approximately 10 times more land cover classes than previous vegetative mapping efforts that resulted in maps of similar type.

In addition, this modified ecological systems classification scheme explicitly incorporates vegetation dynamics and therefore facilitates better ecological interpretations for the biologist and planner. Newly identified remote sensing classification techniques were integrated into the analyses conducted; the result is a vegetative type classification map based on meticulous data analyses that is both usefully interpretative, consistent across geopolitical boundaries, and flexible enough to achieve the desired vegetative analyses needed whether the need is defined at the local, regional, or state planning levels. Phase I and Phase II of the *Ecological Systems Classification and Mapping Project in support of the Texas Comprehensive Wildlife Conservation Strategy* is incorporated by reference to this DEIS.

The vegetative data produced during Phase I and Phase II of the *Ecological Systems Classification and Mapping Project* were analyzed using GIS software, polygon development, and spatial overlay techniques to facilitate vegetative interpretation. From the centerline of the Alternative 3A ROW, a polygon representing the 300-foot wide Alternative 3A ROW was created using ArcMap©. The clipped raster image was converted to the polygon layer and analyzed spatially using a GIS program to aggregate the TPWD vegetation data within the Alternative 3A ROW. Based on the referenced classification scheme, Open Water includes water supply reservoirs (i.e., Lake Livingston and Lake Houston), bays, large ponds (i.e., irrigation ponds), canals, and the Gulf of Mexico and large rivers such as the East Fork San Jacinto River and the Trinity River. Of special note, the Ecological Systems Classification and Mapping Project identified "riparian areas" as that vegetative type located within 30 meters (approximately 133 feet) of streams that are themselves identified as streams by the National Hydrology (NHD) Dataset (<http://nhd.usgs.gov/data.html>). High and low intensity Urban Cover were also classified by this system with a minor area of low intensity Urban Cover identified near the proposed Alternative 3A maintenance facility along SH 321.

Based on the analysis of the TPWD's *Ecological Systems Classification of Texas Project* data within the Alternative 3A ROW, excluding the CRPS, a number of vegetative types were identified as summarized by **Table 4-13**. The summary of direct permanent impacts to vegetation described by the Ecological Systems Classification of Texas Project within the Alternative 3A ROW is provided in **Table 4-16**.

**Table 4-16: Alternative 3A Vegetation Type from TPWD Ecological Systems Classification and Mapping Project**

| Common Name | Description | Alternative 3A (acres) |
|---|---|---|
| Chenier Plain: Mixed Live Oak/Deciduous Hardwood Fringe Forest | Generally occurs over wet soils and may include coastal live oak or loblolly pine mixed with deciduous species, or in some places southern magnolia. Deciduous trees may include laurel oak, water oak, willow oak, cherrybark oak, sweetgum, Hercules-club pricklyash, Chinese tallow, and post oak. | 23.0 |
| Row Crops (Agricultural Fields) | Includes all cropland where fields are fallow for some portion of the year. Some fields may rotate into and out of cultivation frequently, and year-round cover crops are generally mapped as grassland. | 284.0* |
| Gulf Coast: Coastal Prairie | A variety of grasslands are circumscribed by this mapped type, and species such as Bermudagrass, Bahia grass, rat-tail smutgrass, broomsedge bluestem, busy bluestem, brownseed paspalum, and little bluestem may be dominant.<br><br>Shrubs such as baccharis, Chinese tallow, or mesquite may be present. | 176.45 |
| Gulf Coast: Coastal Prairie Pond Shore | Herbaceous or sparse woody cover is characteristic, and species such as sedges, rushes, switchgrass, bushy bluestem, maidencane, and emergent aquatics may be important. Woody species such as Chinese tallow, sweetgum, water oak, sugar hackberry, rattlebox senna may also form sparse overstory cover. | 12.0 |
| Marsh | A variety of small areas of wet soils or alternately wet and dry soils, often near tanks or ponds, are represented within this type. Herbaceous species such as cattails, spikerushes, sedges, and grasses such as Johnsongrass or Bermudagrass may be important. | 0.34 |
| Native Invasive: Deciduous Shrub Land | A variety of shrubs and generally small or sparse deciduous trees may be important in this successional type that was mapped on nonprairie soils. Important species may include water oak, sweetgum, southern red oak, Chinese tallow (south), baccharis, yaupon, winged elm, sugar hackberry, southern dewberry, and elbow-bush. Small pine trees may be present in young, managed plantations. | 0.80 |

| Common Name | Description | Alternative 3A (acres) |
|---|---|---|
| Native Invasive: Deciduous Woodland | This broadly-defined type is mapped on prairie soils and may contain sugar hackberry, cedar elm, water oak, sweetgum, winged elm, and yaupon as important species; Chinese tallow and loblolly pine may be present in the Southeast. | 11.0 |
| Native Invasive: Juniper Shrub Land | This type is mapped on prairie soils or on disturbancesoils and is commonly dominated by eastern redcedar, A variety of deciduous species may also be present, including cedar elm, winged elm, sugar hack berry, sweetgum, water oak and mesquite. In the southeast, loblolly pine is often the dominant tree. | 1.3 |
| Non-Native Invasive: Chinese Tallow Forest, Woodland, or Shrub Land | More or less dense stands of Chinese tallow characterize this type, which is generally mapped over prairie soils. Other component species may include baccharis, sweetgum, water oak, blackgum, loblolly pine, and willow oak. | 149.0 |
| Open Water | Most open water consists of reservoirs, bays, large ponds, canals, and the Gulf of Mexico, although larger rivers are also mapped as open water. | 6.3 |
| Pine Plantation > 3 meters tall | Dense stands of loblolly or mixed loblolly and shortleaf pine characterize this type that is mapped over moist soils where natural pine stands are not expected to occur. Important components may include sweetgum, water oak, blackgum, southern red oak, post oak, and white oak. | 54.0 |
| Pine Plantation 1 to 3 meters tall | Young, planted loblolly pine stands are most common within this type, which is mapped over moist soils where natural pine stands are not expected to occur. Other species such as sweetgum, water oak, winged elm, yaupon, and southern dewberry may also be components. | 6.2 |
| Pineywoods: Bottomland Bald Cypress Swamp | Baldcypress may form nearly pure stands within this mapped type. Other important species may include water tupelo, green ash, overcup oak, willow oak, water elm, common buttonbush, or water hickory. | 0.6 |
| Pineywoods: Bottomland Seasonally Flooded Hardwood Forest | Willow oak, overcup oak (east), sweetgum, green ash, sugar hackberry, cedar elm, swamp post oak, and American elm may be important in this mapped type. Some wetter areas with water elm and baldcypress also occur, and American hornbeam is a common understory species. | 0.7 |

| Common Name | Description | Alternative 3A (acres) |
|---|---|---|
| Pineywoods: Bottomland Temporarily Flooded Hardwood Forest | Deciduous trees such as sweetgum, water oak, sugar hackberry, green ash, willow oak, blackgum, sycamore, black willow, and American elm may be important in this mapped type. American hornbeam, possumhaw and winged elm are common understory species. | 9.4 |
| Pineywoods: Disturbance or Tame Grassland | This mapped type includes many areas dominated by introduced species such as Bermudagrass, Bahia grass, and Johnsongrass. Important components may also include little bluestem, broomsedge bluestem, and hog croton, as well as shrubs such as yaupon and southern dewberry and sparse trees such as post oak and loblolly pine. | 2.9 |
| Pineywoods: Dry Upland Hardwood Forest | This mapped type includes many areas dominated by introduced species such as Bermudagrass, Bahia grass, and Johnsongrass. Important components may also include little bluestem, broomsedge bluestem, and hog croton, as well as shrubs such as yaupon and southern dewberry and sparse trees such as post oak and loblolly pine. | 16.0 |
| Pineywoods: Longleaf or Loblolly Pine/Hardwood Flatwoods or Plantation | Loblolly pine managed forests with a hardwood component characterize this type, but more natural longleaf stands may occur in the south, and slash pine managed forests also occur mainly in the south. Sweetgum, blackgum, water oak, willow oak, and swamp chestnut oak are common canopy trees. | 43.0 |
| Pineywoods: Longleaf or Loblolly Pine** Flatwoods or Plantation | Loblolly pine plantations predominate within this mapped type. Relatively natural longleaf pine stands may occur in the south, and slash pine plantations may also occur. Deciduous trees such as laurel oak, willow oak, water oak, sweetgum, swamp chestnut oak, and blackgum may also be important. | 82.0 |
| Pineywoods: Pine/Hardwood Forest or Plantation | Managed loblolly pine forests are most common within this mapped type, and hardwoods such as sweetgum, water oak, post oak, southern red oak, and cedar elm are common co-dominant species. Shortleaf pine is also a common component and longleaf pine may dominate some areas within its range (southeast). | 1.4 |
| Pineywoods: Pine Forest or Plantation | Managed loblolly pine plantations and forests predominate within this mapped type, and species such as sweetgum, southern red oak, water oak, and post oak are common components. Shortleaf pine is also common, especially to the north or on drier sties, and longleaf pine may be dominant in limited areas within the range of this species (southeast). | 73.0 |

| Common Name | Description | Alternative 3A (acres) |
|---|---|---|
| Pineywoods: Sandhill Oak Woodland | Blackjack oak, post oak, bluejack oak, sand post oak, southern red oak, and sweetgum may be among the dominant trees in this ridge and hilltop type. Loblolly pine, shortleaf pine, and longleaf pine (south) may be components. | 0.8 |
| Pineywoods: Sandhill Pine Woodland | Shortleaf pine, loblolly pine, or longleaf pine (south) may dominate this ridge or hilltop type, and hardwoods such as post oak, blackjack oak, bluejack oak, southern red oak, sand post oak, and sweetgum are often components. | 1.2 |
| Pineywoods: Upland Hardwood Forest | Hardwoods such as sweetgum, post oak, southern red oak, and water oak may be dominant within this mapped type, and loblolly pine or shortleaf pine are common components. Slightly wetter sites may contain species such as white oak and willow oak as important overstory trees. | 76.0 |
| Pineywoods: Wet Hardwood Flatwoods** | Species such as willow oak, sweetgum, laurel oak, water oak, swamp chestnut oak, and overcup oak may be important in these seasonally or temporarily flooded wetlands. Loblolly pine or longleaf pine (south) may also be present. Locally, Chinese tallow may dominate some areas in the south, and dwarf palmetto may form a dense understory in some stands. | 13.0 |
| Swamp | Marsh land or wetlands | 4.0 |
| Urban Low Intensity | This type includes areas that are built-up but not entirely covered by impervious cover, and includes most of the non-industrial areas within cities and towns. | 0.8 |

The primary impact to vegetation resulting from site preparation and construction of the proposed pumping facility, pipeline, and canal would be the removal of vegetation along Alternative 3A. All vegetation within the project ROW would be cleared, resulting in direct impacts to approximately 1,050 acres of vegetative resources, potential wildlife habitat (terrestrial wetlands, woodlands, pasturelands) or agricultural fields containing row crops.

After construction, habitat within the Alternative 3A ROW would be comprised of maintained grassland and riverine habitat types (CESI 2012; **Appendix O**). Various mammal species and predatory bird species would benefit from the edge habitat created by the maintained grassland; while the riverine habitat would provide foraging habitat for wading birds. The riverine habitat would provide a fresh water source to numerous bird, mammal, aquatic and semi-aquatic species.

The Habitat Evaluation Procedure was developed in January 2012 to quantify the ecological value of the Alternative 3A ROW and the proposed 3,000 acre mitigation area and the wildlife habitat available (**Appendix O**) (CESI 2012). Based on the HEP conducted, the removal of existing vegetative and aquatic habitat within the Alternative 3A ROW would decrease the habitat value of the area when compared to the No Action Alternative. The total average annual habitat units (AAHUs) were calculated to be 384.45 for the No Action Alternative and 190.96 for Alternative 3A. After construction and implementation of Alternative 3A, the net loss quantified as AAHUs would be 193.51. **Table 4-17** provides the AAHUs by vegetative and land use cover for Alternative 3A and the No Action Alternative (CESI 2012).

**Table 4-17:**
**Average Annual Habitat Units (AAHUs)**
**by Cover Type for Alternative 3A and No Action**

| Vegetation and Land Use/Land Cover[1] | Description | Alternative 3A AAHU | No Action AAHU |
|---|---|---|---|
| Grasslands | Grasslands are represented by improved Bermuda grass (Cynodon dactylon) pastures that have typically followed from forest clearing. Common forbs include nettles (Solanum sp.), yankeeweed (Eupatorium compostifolium), corn salad, and goldenrod. | 159.51 | 76.02 |
| Agricultural Fields (Cultivated Crops) | Areas actively used for the production of agricultural goods including grain and forage crops. This class also includes all land being actively tilled. | 8.35 | 106.26 |
| Upland Woodlands (Forest) | Areas dominated by trees generally greater than five meters tall and greater than 20 percent of total vegetation cover. This area mostly includes deciduous hardwood forests and some mixed pine-hardwood forests. | 10.64 | 96.69 |
| Evergreen Forest (Uplands) | Areas dominated by juniper shrubland, longleaf or loblolly pine/hardwood flatwoods or plantation forest | 10.24 | 93.06 |
| Bottomland Hardwood Forest (Deciduous Forested Wetlands) | Bottomland hardwood forest typically associated with floodplains such that the dominant trees include willow oak, overcup oak, American elm (*Ulmus americana*), sweet gum (*Liquidambar styraciflua*), sugar hackberry (*Celtis laevigata*), and water oak (*Q. nigra).* Dominant plants in the shrub strata are often small trees, such as those listed above, and include water tupelo (*Nyssa aquatica*), deciduous holly (*Ilex decidua*), and American beautyberry (*Callicarpa americana*). Common vines in the bottomland hardwood forest include green briar (*Smilax* spp.), poison ivy (*Toxicodendron radicans*), trumpet creeper (*Campsis radicans*), and Japanese honeysuckle (*Lonicera japonica*), while common herbaceous plants include lizard's tail, sedges, goldenrod (*Solidago* spp.), and smartweed. | 1.04 | 9.45 |
| Riverine | Emergent, floating, and submergent aquatic vegetation is noticeably absent from the Gillen Bayou. Vegetation overhanging a stream channel typically includes herbs and grasses such as sedges, smartweed, and Indian sea-oats (*Chasmanthium latifolia*). Tree and shrub species include planer-tree (*Planera aquatica),* water oak, swamp privet (*Forestiera acuminata*), and water tupelo (*Nyssa aquatica*). | 0.89 | 0.28 |

| Vegetation and Land Use/Land Cover[1] | Description | Alternative 3A AAHU | No Action AAHU |
|---|---|---|---|
| Woody and Emergent Herbaceous Wetlands | Areas dominated by wetland or riparian plants, including emergent herbaceous vegetation. Herbaceous wetlands dominated by wetland obligates such as rushes, sedges, smartweed, and lizard's tail (Saururus cernuus). Common forbs include goldenrod and morning glory (Ipomoea sp.). Native grasses such as switch grass (Panicum virgatum) and bluestems (Andropogon sp.) are common. | 0.22 | 2.04 |
| Lacustrine | Open water sites with less than 5 percent of the area consisting of emergent vegetation with shrub and tree cover also less than 5 percent | 0.07 | 0.66 |
| **Total AAHUs** | | **190.96** | **384.45** |

*Source: CESI 2012. [1]Vegetation and aquatic cover types evaluated in the HEP analysis were determined using data from the TPWD's Ecological Systems Classifications of Texas project and not the NLCD 2006*

The primary impact to vegetation resulting from site preparation and construction of the proposed pumping facility, pipeline, and canal would be the removal of vegetation along Alternative 3A. All vegetation within the project ROW would be cleared, resulting in direct impacts to approximately 1,050 acres of vegetative resources, potential wildlife habitat (terrestrial wetlands, woodlands, pasturelands) or agricultural fields containing row crops.

After construction, habitat within the Alternative 3A ROW would be comprised of maintained grassland and riverine habitat types (CESI 2012). Various mammal species and predatory bird species would benefit from the edge habitat created by the maintained grassland; while the riparian habitat areas would provide foraging habitat for wading birds. The riparian habitat areas would provide a fresh water source to numerous bird, mammal, aquatic and semi-aquatic species.

### 4.6.7.3 Alternative 4

The area of direct influence for Alternative 4 for terrestrial vegetation and wildlife includes the proposed alternative ROW including roads, pipeline, access roads, drainage ditches, pump and discharge stations, sedimentation basin, maintenance facility and utility lines.

#### 4.6.7.3.1 Evaluation Methodology

Vegetation and land cover types occurring within the Alternative 4 ROW were identified based on the National Land Cover Database of 2006 (NLCD 2006). NLCD 2006 is a 16-class land cover classification scheme for the conterminous United States that was developed at a spatial resolution of 100 feet. NLCD 2006 is based primarily on the classification of Landsat Enhanced Thematic Mapper+ (ETM+) circa 2006 satellite data. These data were used along with GIS analyses of aerial photography to determine the vegetation/land cover types that would be directly affected by the construction of Alternatives 4.

#### 4.6.7.3.2 Environmental Consequences

Alternative 4 is approximately 126,300 linear feet or 23.9 miles in length and would encompass approximately 885 acres within a 300-foot wide ROW; additionally there would be approximately 90 acres required for a pump station and approximately 10 acres required for a maintenance facility. Based on NLCD 2006 data nine terrestrial vegetation types were identified within the Alternative 4 ROW as described in Chapter 3. The existing habitat within the ROW of Alternative 4 is comprised of forested areas, terrestrial wetlands, agricultural land, grazing land, and public land (road ROW). Potential impacts including acres present in the ROW of Alternative 4 and the relative percentages are presented in **Table 4-18**.

#### 4.6.7.4 Alternative 6

The area of direct influence for Alternative 6 for terrestrial vegetation and wildlife includes the proposed ROW including roads, pipeline, access roads, drainage ditches, pump and discharge stations, sedimentation basins, maintenance facility and utility lines.

##### 4.6.7.4.1 Evaluation Methodology

Vegetation and land cover types occurring within the Alternative 6 ROW were identified based on the National Land Cover Database of 2006 (NLCD 2006). NLCD 2006 is a 16-class land cover classification scheme for the conterminous United States that was developed at a spatial resolution of 100 feet. NLCD 2006 is based primarily on the classification of Landsat Enhanced Thematic Mapper+ (ETM+) circa 2006 satellite data. These data were used along with GIS analyses of aerial photography to determine the vegetation/land cover types that would be directly affected by the construction of Alternative 6.

##### 4.6.7.4.2 Environmental Consequences

Alternative 6 is approximately 114,200 linear feet or 21.6 miles in length and would encompass approximately 725 acres within a 300-foot wide ROW; additionally there would be approximately 90 acres required for a pump station and approximately 10 acres required for a maintenance facility. Based on NLCD 2006 data nine terrestrial vegetation types were identified within the Alternative 4 ROW as described in Chapter 3. The existing habitat within the ROW of Alternative 4 is comprised of forested areas, terrestrial wetlands, agricultural land, grazing land, and public land (road ROW). Potential impacts including acres present in the ROW of Alternative 4 and the relative percentages are presented in **Table 4-18** below.

**Table 4-18: Vegetation and Land Use/
Land Cover Data for the Alternatives 4 and 6 ROW**

| Land Cover Type | Alternative 4 | | Alternative 6 | |
|---|---|---|---|---|
| | Acres | Percent | Acres | Percent |
| Cultivated Crops | 97.0 | 11.0 | 116.9 | 16.1 |
| Deciduous Forest | 28.4 | 3.2 | 2.1 | 0.3 |
| Developed, Low Intensity | 3.3 | 0.4 | 20.1 | 2.8 |
| Developed, Medium Intensity | 0.0 | 0.0 | 1.6 | 0.2 |
| Developed, Open Space | 33.9 | 3.8 | 35.7 | 4.9 |
| Emergent Herbaceous Wetlands | 4.0 | 0.5 | 4.8 | 0.7 |
| Evergreen Forest | 58.0 | 6.5 | 15.2 | 2.1 |
| Grassland, Herbaceous | 36.2 | 4.1 | 48.5 | 6.7 |
| Mixed Forest | 16.6 | 1.9 | 18.3 | 2.5 |
| Open Water | 2.8 | 0.3 | 4.3 | 0.6 |
| Pasture, Hay | 318.6 | 36.0 | 241.7 | 33.3 |
| Shrub, Scrub | 47.4 | 5.3 | 18.1 | 2.5 |

| Land Cover Type | Alternative 4 | | Alternative 6 | |
|---|---|---|---|---|
| | **Acres** | **Percent** | **Acres** | **Percent** |
| Woody Wetlands | 239.2 | 27.0 | 197.9 | 27.3 |
| **Total Acres** | **885.4** | | **725.1** | |

Source: NLCD 2006

### 4.6.7.5 Reduction of Potential Impacts

For reduction of unavoidable impacts to the approximately 203 acres of aquatic resources identified within the Alternative 3A ROW, compensatory mitigation would be required by the U.S. Army Corps of Engineers (USACE) to replace the ecological functions and services provided by these aquatic resources. An approximately 3,000 acre parcel of land has been identified for compensatory mitigation using preservation. The Applicant's proposed mitigation property is located adjacent to the Trinity River and surrounds the northeastern portion of the Alternative 3A ROW near the CRPS. The Applicant's proposed mitigation property contains two unique topographical features: Capers Ridge and Gillen Bayou. Capers Ridge is an isthmus of high ground that protrudes into the floodplain of the Trinity River and is approximately 75 feet higher in elevation than the surrounding floodplain. Gillen Bayou is a perennial water body that flows to the east through the southeastern portion of the Applicant's proposed mitigation property.

The habitats located on the Applicant's proposed mitigation property include deciduous and mixed hardwood forested wetlands, bottomland hardwood forests, emergent wetlands, deciduous and evergreen forested uplands, maintained grassland, and fallow pastureland. The Applicant's proposed mitigation property was acquired by Coastal Water Authority (CWA) in 2010 to provide compensation for unavoidable impacts to aquatic resources through preservation. The majority of the Applicant's proposed mitigation property is forested. An area in the southeastern portion of the site has been previously cleared and used as pasture and grazing lands for several decades. Grazing activities have ceased subsequent to CWA acquisition of the property and the pastureland is currently fallow and undergoing succession towards scrub-shrub habitat. Activities of previous landowners have altered the landscape of portions of the Applicant's proposed mitigation property, including clearing of the Trinity River floodplain (pastureland along Gillen Bayou), drainage improvements, timber harvesting activities, hunting, oil and gas exploration, and cattle grazing. Prior to acquisition by the CWA, the compensatory Applicant's proposed mitigation property was also subject to the threat of imminent residential land development and clearing of timber resources by the previous property owners. Compensatory mitigation through preservation of the Applicant's proposed mitigation property would remove the threat of land development and timber activities from the site in perpetuity.

The HEP analysis concluded that the existing vegetative and aquatic habitat within the Applicant 3A mitigation property was similar in habitat value when compared to the No Action Alternative. Based on the HEP analysis conducted, the proposed mitigation property AAHUs were calculated to be 1,413.64 for the No Action Alternative scenario and 1,466.93 for the "with project" scenario (Alternative 3A), resulting in a 53.29 net gain in AAHUs (**Table 4-17**).

**Table 4-18:
Average Annual Habitat Units by
Cover Type within the Proposed Mitigation Property**

| Cover Types within the Proposed Mitigation Property[1] | With Project AAHUs | No Action AAHUs |
|---|---|---|
| Deciduous Forest (Uplands) | 283.45 | 284.64 |
| Deciduous Forest (Wetlands) | 470.43 | 360.15 |
| Evergreen Forest (Uplands) | 690.84 | 691.60 |
| Grasslands | 12.69 | 12.78 |
| Herbaceous Wetlands | 9.52 | 64.47 |
| **Total AAHUs** | **1,466.93** | **1,413.64** |

*Source: CESI 2012.*
*[1]Vegetation and aquatic cover types evaluated in the HEP analysis were determined using data from the TPWD's Ecological Systems Classifications of Texas project and not the NLCD data (2006).*

### 4.6.8 Endangered, Threatened, and Candidate Species, Species of Special Concern, and Sensitive Communities

The area of direct influence for the proposed action alternatives for threatened and endangered species includes the potential location for the ROW including roads, pipeline, canal with access roads and fencing, pump and discharge stations, sedimentation basin, maintenance facility and utility lines, proposed mitigation property as well as the lower Trinity River, Lake Livingston, Lake Houston, and Galveston Bay.

The Federal- and State-listed reptile and amphibian species are discussed in **Chapter 3.8**, Threatened and Endangered Species. Habitat requirements for each were reviewed against the existing vegetation/land cover types and habitat within the project area. The TPWD NDD was reviewed to determine the likelihood that a species could potentially be impacted by the proposed project activities

In October 2009, a threatened and endangered species study was developed for the Alternative 3A project area (CESI 2009, **Appendix D**). Analysis/characterization of habitat and habitat impacts, species specific habitat analysis/characterization, and presence/absence surveys for threatened and/or endangered species were performed in a manner consistent with standard methodologies. Both the USFWS and the TPWD threatened and endangered species lists were reviewed prior to the study.

The USFWS and TPWD were consulted to determine whether the proposed project would affect federally or state listed endangered, threatened, proposed, or candidate plants or animal species. An impacts discussion was included for species whose habitat requirements are found within Alternative 3A ROW. Pedestrian surveys were performed by qualified biologists for the entire ROW. Bird surveys for Alternative 3A ROW were performed by a local bird expert and the findings are provided below (McFarlane 2009 and 2010).

Six species were identified that may be affected, but not adversely affected by the construction, operation, and maintenance activities associated with Alternative 3A (CESI 2009). These species include the Louisiana black bear, Plains spotted skunk, Southeastern myotis, alligator snapping turtle, Louisiana pine snake, and timber/canebrake rattlesnake. These species use a variety of habitat types and no long term impacts to these species are anticipated.

Evaluation of Alternatives 4 and 6 was performed based on the TPWD NDD and data provided during site visits that were conducted for Alternative3A. Site-specific investigations were not perfomed for Alternative 4 and Alternative 6.

### 4.6.8.1 Mammals

The area of direct influence for Alternative 3A for threatened and endangered mammal species includes the lower Trinity River, Lake Livingston, Lake Houston, area agricultural reservoirs, and the Alternative 3A ROW including roads, pipeline, canal, pump and discharge stations, sedimentation basin, maintenance facility, proposed mitigation property, and utility lines.

The Federal- and State-listed mammal species are discussed in **Chapter 3.8,** Threatened and Endangered Species, and habitat requirements for each species were reviewed against the existing vegetation/land cover types and habitat within the project area. The TPWD NDD was reviewed to determine the likelihood that a species potentially could be impacted by the proposed project activities.

#### 4.6.8.1.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur and there would be no impact to threatened and endangered mammalian species that inhabit the existing area or the preferred habitats, likewise, there would be no impacts to the vegetative habitat or to the TPWD species with the concern or rare status.

#### 4.6.8.1.2 Alternative 3A, Alternative 4 and Alternative 6

Based on the review of required and existing habitat within the project area, there are three threatened and endangered mammal species that could potentially be impacted by the construction, operation, and maintenance activities associated with Alternatives 3A, 4, and 6. These include the black bear, the Louisiana black bear, and the Rafinesque's big-eared bat.

The black bear and the Louisiana black bear are listed as possible transients in Liberty County and are known to inhabit bottomland hardwoods and large tracts of inaccessible forested areas. Sub-optimal habitat for this species is present within the bottomland hardwood forest along the Trinity River in the vicinity of the project. The habitat for this species within the project area is confined within an area designated to remain undisturbed and be incorporated into and managed by the TRNWR. No black bears were observed within the proposed project area during the field surveys and no occurrences of black bears are recorded in the TPWD NDD. The construction, operation and maintenance related activities of the proposed project would have no effect on the black bear or Louisiana black bear.

The Rafinesque's big-eared bat roots in tree cavities in bottomland hardwoods, concrete culverts, and abandoned man-made structures. Habitat for this species is present within the hardwood forests along the project alignment. No Rafinesque's big-eared bats were observed within the proposed project area during the field surveys and no occurrences of Rafinesque's big-eared bats are recorded in the TPWD NDD. Due to construction and the clearing of vegetation, the proposed project may impact foraging and nesting habitat of this bat species.

Permanent impacts to wildlife habitat that would result from the proposed action alternatives include a cleared 300-foot wide ROW for the length of each alternative which will be continually mowed and maintained, the decreased attractiveness of habitat adjacent to the project corridor. Temporary impacts include possible disturbances to normal behavior patterns of wildlife as a result of increased noise levels from construction activities.

No state or federally listed threatened, endangered, or species of concern were observed within the Alternative 3A project area during the field studies conducted in 2009 (CESI 2009, **Appendix D**). TPWD provided Element of Occurrence data stating that the listed Rafinesque's big-eared bat occurs within 10 miles of the Alternative 3A project area. The study indicated that construction-related project activities may affect, but are not likely to adversely affect this bat species.

The construction of Alternatives 3A, 4 and 6 would result in direct, long-term impacts on wildlife habitat, including habitat loss through its conversion to surface water conveyance infrastructure and maintained ROW. Wildlife in the project area has and would continue to be dominated by species that are better able to adapt to a disturbed physical environment and could tolerate possible disturbances from the proposed project. Although construction of the build alternative would remove and/or convert habitat and therefore displace wildlife in certain areas, habitat loss and the resulting effects on wildlife would be expected to be minor. Impacts to habitat used by local wildlife would be limited to the proposed action alternatives ROW.

### 4.6.8.2 Reptile and Amphibians

The area of direct influence for the proposed action alternatives for threatened and endangered reptiles and amphibians includes the lower Trinity River, Lake Livingston, Lake Houston at the discharge location near the confluence with Luce Bayou, and Galveston Bay.

#### 4.6.8.2.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur and there would be no impact to threatened and endangered reptilian or amphibian species that inhabit the existing area or the preferred habitats, likewise, there would be no impacts to the vegetative habitat or to the TPWD species with the concern or rare status.

#### 4.6.8.2.2 Alternative 3A, Alternative 4 and Alternative 6

Based on the review of required and existing habitat within the project area, there are three threatened and endangered reptile and amphibian species that could potentially be impacted by the construction, operation, and maintenance activities associated with Alternatives 3A, 4 and 6. These species were also identified as those that may be affected, but not adversely affected by the construction, operation, and maintenance activities associated with Alternative 3A (CESI 2009). These species include the alligator snapping turtle, Louisiana pine snake, and timber/canebrake rattlesnake. These species use a variety of habitat types and no long term impacts to these species are anticipated.

### 4.6.8.3 Birds

The area of direct influence for the proposed action alternatives for threatened and endangered bird species includes the lower Trinity River, Lake Livingston, Lake Houston, agricultural reservoirs, and the action alternatives ROW including roads, pipeline, canal, pump and discharge stations, sedimentation basin, maintenance facility, proposed mitigation property, and utility lines.

The Federal- and State-listed birds species are discussed in Section 3.8, Threatened and Endangered Species, and habitat requirements for each species were reviewed against the existing vegetation/land cover types and habitat within the project area. The TPWD Natural Diversity Database (NDD) was reviewed to determine the likelihood that a species could potentially be impacted by the proposed action alternatives activities.

#### 4.6.8.3.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur and there would be no impact to threatened and endangered species including birds, fish, freshwater mussel species, mammals, reptiles, amphibians, or vegetation communities that inhabit the existing area or the preferred habitats, likewise, there would be no impacts to the vegetative habitat or to the TPWD species with the concern or rare status.

#### 4.6.8.3.2 Alternative 3A, Alternative 4, Alternative 6

Ten bird species that could potentially be impacted by the construction, operation and maintenance of the proposed action alternatives include the peregrine falcon, Bachman's sparrow, bald eagle, brown pelican, whooping crane, piping plover, red-cockaded woodpecker (RCW), swallow-tailed kite, white-faced ibis, and wood stork.

With the exception of the Bald Eagle and the Swallow-Tailed Kite as detailed in Chapter 3, there is no suitable habitat identified for any rare, threatened, or endangered bird species within the LBITP area for Alternative 3A and is unlikely in the ROW of Alternatives 4. Implementation of Alternative 4 would not be expected to directly and permanently impact terrestrial bird species given that monitoring for the presence of these species will occur prior to planned construction.

### 4.6.8.4 Fish and Freshwater Mussels

The area of direct influence for Alternative 3A, Alternative 4 and Alternative 6 for threatened and endangered fish and freshwater mussels includes the potential location for the proposed alternatives, including the lower Trinity River, Lake Livingston, Lake Houston at the discharge location near the confluence with Luce Bayou, and Galveston Bay.

The Federal- and State-listed fish and freshwater water mussel species are discussed in **Chapter 3.8**, Threatened and Endangered Species, and habitat requirements for each were reviewed against the existing vegetation/land cover types and habitat within the project area, and the TPWD NDD were reviewed to determine the likelihood that a species potentially could be impacted by the proposed action alternatives.

#### 4.6.8.4.1 Alternative 3A, Alternative 4, Alternative 6

According to studies conducted, mussels that inhabit the lower Trinity River and Lake Houston are not known to include rare unionid species currently being considered for State or Federal listing (Howells 2009). According to investigations conducted, Alternative 3A, Alternative 4 and Alternative 6 would not be expected to have direct impacts on mussel species that are candidates for State or Federal listing or to pose major threat to existing unionid populations.

Impacts to fish and freshwater mussels can occur from construction within the watershed, such as dredging, trenching, or soil and fill runoff. Effects from such activities include excessive sedimentation, changes in water flow and speed, and exposure from clearing out debris where mussels might take shelter. The construction of the proposed pumping station and outflow would require construction activities within the Trinity River and the backwaters of Lake Houston near Luce Bayou. Freshwater mussels and benthic species located at these locations would likely be removed. After construction and water is returned, benthic organism and mussels would likely recolonize the area.

Impacts to freshwater mussels are also known to occur from the introduction of exotic bivalves, such as Asian clams or zebra mussels. The Fish and Freshwater Mussels section of this chapter provides detailed information on mussel studies conducted for the proposed project and the potential risks associated with zebra mussels.

Pumping at the CRPS and TRPS could impinge larger fish on intake screens, and entrain fish eggs and mussel larvae through the transfer system. The proposed project would utilize a trash rack and screening that would impact aquatic species that could potentially get caught and trapped. Although there would be a risk of impingement and entrainment on the pump intake screens at the Capers Ridge Pump Station, during typical pumping operations, the intake screen design would control approach velocities at the Trinity River intake structure. During normal flow conditions, the intake approach velocities would be approximately 0.4 feet/second (ft/sec). The anticipated approach velocity would be expected to reduce the effect of the action alternatives on fish and nekton of the Trinity River. In addition, the proposed intake screens would be constructed in the banks of the channel. The location of these screens within the channel bank also could potentially reduce the risk of entrainment.

The screens would be designed to allow smaller- to medium-sized organisms to pass through, which would reduce mortality on nektonic species that may be incidentally discharged into Alternative 3A conveyance channel canal.

### 4.6.8.5 Plants

The area of direct influence for Alternative 3A for threatened and endangered plants includes the potential location for the Alternative 3A ROW and the lower Trinity River, Lake Livingston, Lake Houston at the discharge location near the confluence with Luce Bayou, and Galveston Bay.

The Federal- and State-listed plants species discussed in **Chapter 3.8**, Threatened and Endangered Species, and habitat requirements for each were reviewed against the existing vegetation/land cover types and habitat within the project area, and the TPWD NDD were reviewed to determine the likelihood that a species potentially could be impacted by the proposed project activities.

#### 4.6.8.5.1 Alternative 3A, Alternative 4, and Alternative 6

The Texas Prairie Dawn is State and Federally-listed as endangered in Harris County. This plant is found in sparsely vegetated, open grasslands with fine sandy compacted saline soil in poorly drained depressions around natural mima (pimple) mounds (USFWS 1989). Field investigations revealed that the Texas Prairie Dawn does not occur within the proposed ROW and that soil conditions have been altered making them unsuitable to support this plant species. The proposed action alternatives would have no impact on the Texas Prairie Dawn plant.

### 4.6.8.6 TPWD's Species of Concern/Rare Species

The area of direct influence for Alternative 3A for threatened and endangered plants includes the potential location for the Alternative 3A ROW and the lower Trinity River, Lake Livingston, Lake Houston at the discharge location near the confluence with Luce Bayou, and Galveston Bay.

The State-listed plant and wildlife species were discussed in Section 3.8, Threatened and Endangered Species and habitat requirements for each were reviewed against the existing vegetation/land cover types and habitat within the project area, and the TPWD NDD was reviewed to determine the likelihood that a species potentially could be impacted by the proposed action alternatives.

#### 4.6.8.6.1 Alternative 3A, Alternative 4, and Alternative 6

Suitable habitat occurs within the proposed project ROW to support seven TPWD species listed with concern or rare status. These species include: Henslow's sparrow, mountain plover, American eel, Gulf Coast clubtail fish, plains spotted skunk, southeastern myotis bat, and Texas meadow-rue. Suitable habitat within the ROW would be removed during construction resulting in species being forced to move to adjacent habitats or, potentially, less mobile species could be eliminated. No rare species were identified during the field investigations and no known occurrences are documented in the vicinity of the proposed project in TPWD's NDD.

### 4.6.8.7 Reduction and Mitigation of Potential Impacts

Mitigation is typically species specific and is therefore addressed by species category identified below in the following subsections of this DEIS.

#### 4.6.8.7.1 Birds

The Alternative 3A alignment was changed through the agricultural fields and now avoids a reservoir with a rookery in the northern portion of Parcels 28 through 32. This new alignment bypasses the reservoir, thereby eliminating unavoidable impacts to this reservoir that would have reduced its volume capacity and disturbed the ecological value of this site as a wading bird rookery. During the construction of the proposed project, qualified biologists would inspect the area for occurrences of threatened and/or endangered bird species; including migratory bird species.

#### 4.6.8.7.2 Fish and Freshwater Mussel Species

Monitoring at the proposed pump station would occur during operation and maintenance to determine if the new pump station has measureable effect on the recreational fish species. In addition, monitoring at the discharge point at Lake Houston near the Luce Bayou confluence would be conducted to determine the success rate of recreational fish species re-inhabiting the area.

Mitigation measures to consider for the zebra mussel include establishing monitoring procedure at the 11 stations examined in the San Jacinto and lower Trinity River watersheds along with stations in Lake Conroe, Lake Livingston, and Lake Houston (McMahon 2012).

#### 4.6.8.7.3 Mammals

During the construction of the proposed project, qualified biologists would be on site to monitor for mammal species activity.

#### 4.6.8.7.4 Reptiles and Amphibians

During the construction of the proposed project, qualified biologists would be on site to monitor for reptile or amphibian species activity.

#### 4.6.8.7.5 Plants

Because the soils within the proposed project area are unsuitable to support the Texas prairie dawn plant and no impacts would occur to this species, no mitigation is proposed for this plant species.

#### 4.6.8.7.6 Species of Concern/Rare Species

During the construction of the proposed project, qualified biologists would be on site to monitor for wildlife species activity.

## 4.6.9 Nuisance, Exotic and Invasive Species

### 4.6.9.1 Federal Regulations

Under the Aquatic Nuisance Prevention and Control Act of 1990 (Act), the Aquatic Nuisance Species Task Force (16 U.S.C. 4721) was authorized. The Aquatic Nuisance Species Task Force (Task Force) was mandated to develop and implement a program to prevent introduction and dispersal of aquatic nuisance species; to monitor, control and study such species; and, to disseminate related information (16 U.S.C. 4722). The Assistant Secretary of the Army (Civil Works) was empowered by this Act to direct the Task Force and to develop a program of research and technology development for controlling zebra mussels in and around public facilities and to collect and make public information related to methods of control of zebra mussels and other nuisance species. The Act stated that the Assistant Secretary [Civil Works] would review proposed public facility management plans for requirements to reduce infestations of zebra mussels and approve the management plans if they meet the requirements specified in the Act (16 U.S.C. 4724).

Zebra mussels have been recently discovered in the Trinity River basin above Lake Lavon, Texas and are thought to have been transferred from Lake Texoma. Lake Texoma is a reservoir constructed by the USACE on the Red River that was operational in 1944. The Red River forms the state boundary between Texas and Oklahoma. It is thought that the zebra mussels reached Oklahoma from barge traffic through the Mississippi River and Arkansas River systems. Invasive species controls by the USACE Fort Worth and Tulsa Districts have been implemented to control the spread of the zebra mussel in Lake Texoma and upstream of Lake Lavon. Lake Lavon is the headwaters of the Trinity River and is located approximately 400 miles upstream of the proposed LBITP project.

A September 10, 2010 article in the Dallas Morning News chronicled the efforts of Texas Parks and Wildlife Department (TPWD) technicians to eradicate zebra mussels from West Fork Sister Grove Creek where the outfall structure is located that discharges water from Lake Texoma to Lake Lavon. At the outfall structure, the West Fork Sister Grove Creek is an intermittent to perennial stream with no public access. Pumping of water from Lake Texoma has ceased at the request of the USACE. As of December 8, 2010, the North Texas Water Supply District that obtains water from Lake Texoma has requested that additional water from Lake Ray Hubbard and Lake Sam Rayburn be available since water from Lake Texoma is still unusable due to zebra mussel concerns.

The TPWD has been working with local, state and Federal agencies to develop a plan for dealing with the zebra mussel. During sampling activities conducted by the TPWD in October 2009, no evidence of an active population of zebra mussels in Lake Lavon, (headwaters of the Trinity River, downstream of Lake Texoma on the Oklahoma-Texas border), was identified. However, the USACE Tulsa District and the TPWD are continuing the monitoring of these organisms in areas downstream of Lake Texoma.

The TPWD worked with an inter-agency group comprised of the Texas Commission on Environmental Quality (TCEQ), Texas Department of Agriculture (TDA) and the U.S. Environmental Protection Agency (EPA) to obtain the necessary permits and approvals to treat West Fork Sister Grove Creek upstream of Lake Lavon in October 2010. The treatment plan took several months to develop. Different eradication options and chemicals were considered and the creek was surveyed and the hydrology measured. The TPWD used potassium chloride (KCl), a chemical used to soften water and a natural component of human diet, in their effort to eradicate zebra mussels from West Fork Sister Grove Creek. The target concentration of KCl was 175 parts per million (ppm), a concentration sufficient to kill zebra mussels, but well below the 250 ppm allowed by the EPA in public drinking water supplies. After the water from the creek reached Lake Lavon, it was diluted and the concentration of KCl was even lower. Potassium does not harm other species, but appears to kill zebra mussels by interfering with the ability of their gills to take in oxygen from the water.

There is a general acknowledgement that there is a lack of large-scale, effective means to control the spread of invasive species, specifically zebra mussels, in water systems after their introduction. This is related in part to the passive nature of the dispersal of these species. At this time, although not succeeding based on recent reports (Dallas News dated July 2012), containment is generally acknowledged to be the best defense for invasive species control.

## 4.6.9.2 Reduction and Mitigation of Potential Impacts

### 4.6.9.2.1 Zebra Mussels

Mitigation measures for the zebra mussel may include establishing monitoring procedures at the 11 stations examined in the San Jacinto and Lower Trinity River watersheds along with stations in Lake Conroe, Lake Livingston, and Lake Houston (McMahon 2012). **Appendix P** includes the Luce Bayou Interbasin Transfer Project Zebra Mussel Control Plan, which outlines methods for the reduction of potential impacts if and when zebra mussels become a problem for the LBITP. An effective plan would include a multi-barrier approach using a variety of control measures at different facility locations.

### 4.6.9.2.2 Giant Salvinia

Giant salvinia salvinia is a non-native aquatic plant that grows rapidly through vegetative reproduction and is tolerant of environmental stress, thereby making it an aggressive species competing with native aquatic vegetation and ecosystems. Giant salvinia is known to occur in both the San Jacinto River and Trinity River watersheds. It is reported to be in Lake Conroe and Sheldon Reservoir. Large infestations have not affected Lake Houston, but the Coastal Water Authority is aware of infested areas outside of Lake Houston. The CWA has staff trained in the identification and treatment of giant salvinia. The proposed water conveyance canal could provide a pathway for the incidental movement of giant salvinia from the Trinity River to Lake Houston, but since the plant is already present in both watersheds, the conveyance canal would not be the cause or the reason for the introduction of giant salvinia into the San Jacinto River watershed. Because of the physical characteristics of the aquatic habitat at the proposed Trinity River pump station site, and the filtering capacity and function of the intake screens, the potential for the incidental transfer of aquatic vegetation would be minimal. However, the CWA is keenly aware of the extremely invasive character of giant salvinia; has developed monitoring and control procedures for other projects; and understands that early identification and treatment are paramount to control the spread of the plant. The CWA will develop and incorporate physical and/or chemical measures, as appropriate, into its management plan for the operation and maintenance of the conveyance canal to control giant salvinia.

Because of the physical characteristics of the aquatic habitat at the proposed CRPS, and the filtering capacity and function of the intake screens, the potential for the incidental transfer of aquatic vegetation would be minimal. However, the CWA is keenly aware of the extremely invasive character of giant salvinia, has developed monitoring and control procedures for other projects, and understands that early identification and treatment are paramount to control the spread of the plant. The CWA will develop and incorporate physical and/or chemical measures, as appropriate, into its management plan for the operation and maintenance of the conveyance canal to control giant salvinia.

## 4.7 Land Use and Recreation

Major metropolitan areas such as Houston and Dallas are dealing with projected population and land use growth. Geographic based evaluation of land use change can be understood based on the land use history, population data, timelines of historical events, and related information. Population data can be correlated to a temporal geographic data and population growth suggests economic growth and the availability of jobs in an area; similarly, population declines suggest a decline in livability or economic issues. Timelines of past events and other historical compilation aid in identifying the issues that may have affected and may continue to affect development of an area or region.

In addition to population statistics and historical land use information, a physiographic analysis can identify how these factors affect land use and land use changes. Topographic features, climate, and adequate supplies of water and other natural resources can limit or encourage growth and change. The existence and accessibility of transportation routes have often guided or influenced urban growth. The dependence of populations on the private automobile has resulted in the expansion of development at the margin or fringe of urban areas. As road networks expanded and became more complicated, urban development has followed. As in the past, recent urban development and population growth has occurred along transportation corridors.

### 4.7.1 No Action

As part of No Action, the proposed project would not be constructed or operated and water would not be withdrawn from the Trinity River for municipal water supply. In addition, land acquired for the proposed LBITP and described as woody wetlands, cultivated crops, pasture/hay, mixed, evergreen, or deciduous forest, or open water would not be preserved as part of the proposed mitigation plan (**Chapter 6**) or converted to public use (i.e., the area needed to implement the LBITP).

### 4.7.2 Alternative 3A

The area directly influenced by Alternative 3A for land use includes the potential location for the Alternative 3A ROW. Creating a route for a water conveyance system would require that the Applicant acquire land to maintain the system ROW. Agricultural, open space or timberland would be converted from current ownership to public use through property acquisition. The predominantly privately-owned land within the proposed ROW of the canal alignment would be converted to public use and would lose the current value it might possess for agricultural or timber production.

All components of Alternative 3A would be located in a sparsely populated, rural area of Liberty County and northeastern Harris County, Texas. The cities of Huffman and Dayton and the town of Kenefick are in the vicinity of the project. **Table 4-19** summarizes the property parcels traversed by Alternative 3A, the parcel identification number, the size of each property by parcel number, the parcel acres to be taken by Alternative 3A, and the percent of each parcel that would be acquired within the proposed ROW. Excluding mitigation property, two parcels totaling approximately 15.34 acres would be acquired in total (100 percent) for implementation of Alternative 3A. The remaining percent of the approximate 49 parcels would be acquired by percentage estimates that range from 39 to less than 1 percent of the total acreage within each parcel. The median acquisition percentage by parcel for the remaining 49 parcels within Alternative 3A ROW is approximately 14 percent.

Construction, operation, and maintenance of Alternative 3A would permanently convert approximately 1,050 acres of land described as woody wetlands, cultivated crops, pasture/hay, mixed, evergreen or deciduous forest, or open water land use to public water utility use. The percent change in land use in a parcel-by-parcel basis and total for Alternative 3A are summarized in **Table 4-19**.

For Alternative 3A, 1,050 acres of land would be the minimum amount needed to construct and operate the proposed project. Alternative 3A in Harris County and Liberty County is located in areas without zoning regulations or restrictions. Land use in residential areas may be subject to deed restrictions and homeowner association requirements, although Alternative 3A area is relatively sparsely populated with limited residential development. Mineral, sand and gravel, hunting, agricultural and other leases may be associated with specific parcels within Alternative 3A ROW. There would be a direct, significant public benefit that would occur to change from private to public ownership of the 1,050 acres needed for the implementation of Alternative 3A. The construction, operation, and maintenance of Alternative 3A would not affect or be impacted by land use controls or zoning.

**Table 4-19:**
**Percentage Change of Land Use, Estimated Acreage and Percent Impact by Parcel Intersecting Alternative 3A**

| Parcel No. | Parcel Area (acres) | Alternative 3A Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 1 | 90.50 | 48.27 | 53.34 |
| 4 | 1,175.38 | 70.31 | 5.98 |
| 4.5 | 1,047.99 | 61.40 | 5.86 |
| 6 | 481.41 | 14.64 | 3.04 |
| 6 | 157.15 | 20.38 | 12.97 |
| 7 | 2,045.55 | 61.75 | 3.02 |
| 8 | 1,041.75 | 17.21 | 1.65 |
| 9 | 76.81 | 6.20 | 8.07 |
| 10 | 730.48 | 30.08 | 4.12 |
| 11 | 19.22 | 0.18 | 0.95 |
| 12 | 296.60 | 24.93 | 8.40 |
| 13 | 918.20 | 2.70 | 0.29 |
| 14 | 53.53 | 16.18 | 30.22 |
| 15 | 3.83 | 0.95 | 24.71 |
| 16 | 7.59 | 3.49 | 46.02 |
| 17 | 14.84 | 4.96 | 33.39 |
| 19 | 128.02 | 10.07 | 7.87 |
| 20 | 52.89 | 3.39 | 6.40 |

| Parcel No. | Parcel Area (acres) | Alternative 3A Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 21 | 71.51 | 16.79 | 23.48 |
| 22 | 32.68 | 12.76 | 39.03 |
| 23.2 | 879.06 | 83.61 | 9.51 |
| 23.4 | 527.80 | 9.28 | 1.76 |
| 25.2 | 30.61 | 14.78 | 48.29 |
| 25.4 | 6.04 | 0.34 | 5.70 |
| 25.4 | 6.01 | 0.34 | 5.73 |
| 25.6 | 627.86 | 35.88 | 5.72 |
| 27 | 49.94 | 11.88 | 23.79 |
| 28 | 31.69 | 3.63 | 11.45 |
| 29 | 31.72 | 3.62 | 11.42 |
| 30 | 26.50 | 3.02 | 11.41 |
| 31 | 20.03 | 2.27 | 11.35 |
| 32 | 28.21 | 2.26 | 8.02 |
| 33 | 449.75 | 44.06 | 9.80 |
| 37.5 | 355.94 | 23.56 | 6.62 |
| 39.2 | 11.61 | 6.55 | 56.41 |
| 39.2 | 6.76 | 4.07 | 60.17 |
| 39.4 | 34.68 | 1.74 | 5.03 |
| 39.6 | 86.99 | 9.76 | 11.21 |
| 39.6 | 24.93 | 4.43 | 17.76 |
| 39.6 | 10.01 | 1.78 | 17.76 |
| 39.6 | 86.03 | 9.65 | 11.21 |
| 39.8 | 100.63 | 27.65 | 27.47 |
| 40.5 | 249.73 | 32.37 | 12.96 |
| 41 | 46.75 | 11.72 | 25.07 |
| 42 | 200.36 | 30.96 | 15.45 |
| 43.1 | 198.87 | 19.73 | 9.92 |
| 43.2 | 22.47 | 2.37 | 10.53 |
| 43.3 | 253.07 | 26.63 | 10.52 |
| 43.4 | 0.92 | 0.58 | 63.73 |
| 43.5 | 0.93 | 0.65 | 69.78 |
| 44 | 962.10 | 17.56 | 1.83 |
| 44.5 | 2.74 | 0.48 | 17.71 |
| 45 | 18.02 | 5.37 | 29.78 |
| 46 | 11.99 | 3.22 | 26.87 |
| 46.5 | 8.72 | 1.52 | 17.45 |
| 48 | 11.85 | 11.85 | 99.96 |
| 49 | 11.83 | 3.91 | 33.09 |
| 50 | 390.31 | 61.98 | 15.88 |
| 51 | 32.58 | 9.90 | 30.38 |
| 52 | 79.63 | 22.87 | 28.72 |
| 53 | 26.86 | 7.87 | 29.31 |

| Parcel No. | Parcel Area (acres) | Alternative 3A Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 54 | 1.28 | 0.17 | 13.23 |

Parcel Area Source: National Land Cover Database (2006) (also see **Appendix R**)

### 4.7.3 Alternative 4

Construction, operation, and maintenance of Alternative 4 would permanently convert approximately 985 acres of land described as woody wetlands, cultivated crops, pasture/hay, mixed, evergreen, or deciduous forest, or open water land use to public water utility use. The percent change in land use in a parcel-by-parcel basis and total for Alternative 4 are summarized in **Table 4-20**.

For Alternative 4, approximately 985 acres of land would be the minimum amount needed to construct and operate the proposed project. Alternative 4 in Harris County and Liberty County is located in areas without zoning regulations or restrictions. Land use in residential areas may be subject to deed restrictions and homeowner association requirements, although Alternative 4 area is relatively sparsely populated with limited residential development. Mineral, sand and gravel, hunting, agricultural and other leases may be associated with specific parcels within Alternative 4 ROW. There would be a direct, significant public benefit that would occur to change from private to public ownership of the 985 acres needed for the implementation of Alternative 4. The construction, operation, and maintenance of Alternative 4 would not affect or be impacted by land use controls or zoning. The percent change in land use in a parcel-by-parcel basis and total for Alternative 4 are summarized below**.**

**Table 4-20:**
**Percentage Change of Land Use, Estimated Acreage and Percent Impact by Parcel Intersecting Alternative 4**

| Parcel No. | Parcel Area (acres) | Alternative 4 Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 1 | 90.50 | 20.81 | 22.99 |
| 2 | 841.73 | 0.50 | 0.06 |
| 3 | 1,175.42 | 36.30 | 3.09 |
| 4 | 1,048.03 | 38.46 | 3.67 |
| 5 | 500.69 | 2.64 | 0.53 |
| 6 | 638.60 | 32.21 | 5.04 |
| 7 | 2,045.71 | 41.67 | 2.04 |
| 8 | 1,041.82 | 17.23 | 1.65 |
| 9 | 21.28 | 1.64 | 7.69 |
| 10 | 76.82 | 4.20 | 5.46 |
| 11 | 19.22 | 1.88 | 9.79 |
| 12 | 730.55 | 19.55 | 2.68 |
| 13 | 296.63 | 5.24 | 1.77 |
| 14 | 918.29 | 9.93 | 1.08 |
| 15 | 73.84 | 6.83 | 9.25 |
| 16 | 153.52 | 4.47 | 2.91 |
| 17 | 5.78 | 0.30 | 5.16 |
| 18 | 10.31 | 3.71 | 36.00 |
| 19 | 4.24 | 0.14 | 3.20 |
| 20 | 97.53 | 9.61 | 9.85 |

| Parcel No. | Parcel Area (acres) | Alternative 4 Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 21 | 3.52 | 0.01 | 0.17 |
| 22 | 1.11 | 0.00 | 0.43 |
| 23 | 2.02 | 0.30 | 14.78 |
| 24 | 34.11 | 5.44 | 15.95 |
| 25 | 132.89 | 7.54 | 5.67 |
| 26 | 245.35 | 19.99 | 8.15 |
| 27 | 246.68 | 6.14 | 2.49 |
| 28 | 80.08 | 12.68 | 15.84 |
| 29 | 10.60 | 0.91 | 8.58 |
| 30 | 9.45 | 0.54 | 5.68 |
| 31 | 11.09 | 0.03 | 0.24 |
| 32 | 1,232.26 | 16.35 | 1.33 |
| 33 | 233.96 | 18.99 | 8.11 |
| 34 | 67.69 | 7.14 | 10.55 |
| 35 | 29.77 | 1.24 | 4.15 |
| 36 | 9.34 | 0.42 | 4.52 |
| 37 | 25.38 | 0.00 | 0.01 |
| 38 | 24.39 | 7.52 | 30.84 |
| 39 | 27.22 | 4.32 | 15.88 |
| 40 | 28.15 | 1.80 | 6.38 |
| 41 | 273.04 | 13.95 | 5.11 |
| 42 | 90.92 | 2.41 | 2.65 |
| 43 | 28.33 | 6.49 | 22.92 |
| 44 | 9.71 | 0.44 | 4.51 |
| 45 | 10.19 | 1.10 | 10.76 |
| 46 | 10.32 | 1.83 | 17.76 |
| 47 | 9.49 | 1.27 | 13.36 |
| 48 | 30.08 | 0.34 | 1.12 |
| 49 | 10.58 | 1.47 | 13.94 |
| 50 | 11.33 | 1.87 | 16.49 |
| 51 | 22.88 | 2.59 | 11.32 |
| 52 | 11.63 | 0.78 | 6.73 |
| 53 | 11.58 | 0.46 | 3.97 |
| 54 | 11.93 | 0.02 | 0.14 |
| 55 | 14.90 | 0.34 | 2.29 |
| 56 | 16.83 | 1.56 | 9.26 |
| 57 | 20.94 | 3.98 | 18.99 |
| 58 | 11.79 | 2.35 | 19.92 |
| 59 | 12.11 | 2.39 | 19.71 |
| 60 | 12.34 | 2.42 | 19.61 |
| 61 | 15.50 | 3.07 | 19.82 |
| 62 | 1.65 | 0.33 | 20.29 |
| 63 | 7.06 | 1.37 | 19.41 |

| Parcel No. | Parcel Area (acres) | Alternative 4 Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 64 | 32.56 | 3.24 | 9.94 |
| 65 | 12.34 | 1.71 | 13.87 |
| 66 | 16.19 | 2.52 | 15.59 |
| 67 | 42.43 | 3.88 | 9.15 |
| 68 | 66.09 | 0.01 | 0.01 |
| 69 | 47.01 | 7.50 | 15.96 |
| 70 | 10.48 | 0.16 | 1.53 |
| 71 | 7.96 | 0.86 | 10.82 |
| 72 | 13.81 | 1.56 | 11.30 |
| 73 | 10.81 | 2.08 | 19.20 |
| 74 | 8.84 | 1.64 | 18.57 |
| 75 | 8.93 | 1.73 | 19.42 |
| 76 | 83.14 | 0.18 | 0.21 |
| 77 | 10.61 | 2.86 | 26.96 |
| 78 | 9.46 | 2.89 | 30.58 |
| 79 | 5.65 | 1.35 | 23.94 |
| 80 | 5.30 | 1.46 | 27.58 |
| 81 | 10.77 | 3.05 | 28.29 |
| 82 | 24.17 | 1.08 | 4.47 |
| 83 | 95.67 | 0.06 | 0.06 |
| 84 | 3.49 | 0.79 | 22.76 |
| 85 | 2.44 | 1.26 | 51.53 |
| 86 | 2.42 | 1.13 | 46.90 |
| 87 | 2.14 | 0.29 | 13.48 |
| 88 | 1.27 | 0.35 | 27.85 |
| 89 | 3.70 | 0.66 | 17.94 |
| 90 | 5.21 | 0.45 | 8.62 |
| 91 | 23.26 | 1.42 | 6.10 |
| 92 | 9.82 | 2.77 | 28.17 |
| 93 | 4.16 | 0.66 | 15.95 |
| 94 | 13.39 | 2.18 | 16.27 |
| 95 | 2.10 | 0.02 | 0.88 |
| 96 | 8.35 | 3.74 | 44.83 |
| 98 | 9.16 | 4.41 | 48.13 |
| 99 | 6.09 | 0.37 | 6.00 |
| 100 | 32.24 | 0.02 | 0.05 |
| 101 | 33.82 | 0.02 | 0.06 |
| 102 | 29.79 | 2.94 | 9.87 |
| 103 | 29.60 | 3.82 | 12.89 |
| 104 | 4.82 | 1.99 | 41.36 |
| 105 | 1.03 | 0.07 | 7.14 |
| 106 | 30.36 | 4.30 | 14.16 |
| 107 | 4.41 | 0.54 | 12.23 |

| Parcel No. | Parcel Area (acres) | Alternative 4 Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 108 | 4.40 | 3.63 | 82.42 |
| 109 | 4.50 | 0.72 | 16.00 |
| 110 | 0.53 | 0.00 | 0.19 |
| 111 | 8.50 | 1.52 | 17.92 |
| 112 | 3.34 | 1.63 | 48.78 |
| 113 | 6.72 | 4.10 | 60.98 |
| 114 | 5.80 | 2.35 | 40.58 |
| 115 | 7.16 | 0.50 | 6.96 |
| 116 | 27.29 | 0.60 | 2.20 |
| 117 | 24.26 | 8.87 | 36.55 |
| 118 | 19.56 | 3.58 | 18.29 |
| 119 | 183.49 | 14.10 | 7.69 |
| 120 | 153.36 | 1.92 | 1.25 |
| 121 | 59.91 | 8.16 | 13.62 |
| 122 | 17.28 | 4.20 | 24.32 |
| 123 | 15.14 | 3.82 | 25.24 |
| 124 | 3.15 | 1.40 | 44.31 |
| 125 | 1.01 | 1.00 | 98.86 |
| 126 | 5.26 | 0.72 | 13.76 |
| 127 | 9.17 | 1.71 | 18.63 |
| 128 | 10.00 | 1.90 | 18.96 |
| 129 | 9.69 | 1.83 | 18.88 |
| 130 | 12.46 | 2.32 | 18.64 |
| 131 | 20.72 | 0.77 | 3.73 |
| 132 | 88.59 | 2.60 | 2.93 |
| 133 | 10.03 | 0.08 | 0.77 |
| 134 | 20.00 | 1.38 | 6.89 |
| 135 | 10.01 | 1.23 | 12.33 |
| 136 | 10.03 | 1.24 | 12.38 |
| 137 | 23.04 | 2.36 | 10.26 |
| 138 | 23.10 | 5.35 | 23.17 |
| 139 | 11.17 | 4.95 | 44.32 |
| 140 | 11.64 | 2.21 | 19.00 |
| 141 | 11.25 | 0.00 | 0.02 |
| 142 | 561.16 | 30.36 | 5.41 |
| 143 | 857.91 | 10.60 | 1.24 |
| 144 | 306.07 | 14.80 | 4.83 |
| 145 | 9.99 | 0.84 | 8.42 |
| 146 | 47.39 | 0.20 | 0.43 |
| 147 | 0.88 | 0.24 | 27.82 |
| 148 | 0.69 | 0.29 | 41.93 |
| 149 | 0.72 | 0.25 | 34.98 |
| 150 | 0.51 | 0.04 | 7.27 |

| Parcel No. | Parcel Area (acres) | Alternative 4 Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 151 | 0.41 | 0.08 | 20.68 |
| 152 | 0.48 | 0.10 | 19.85 |
| 153 | 0.54 | 0.54 | 99.50 |
| 154 | 0.50 | 0.50 | 99.12 |
| 155 | 0.46 | 0.46 | 100.23 |
| 156 | 0.47 | 0.45 | 96.07 |
| 157 | 0.46 | 0.43 | 93.23 |
| 158 | 0.44 | 0.35 | 79.14 |
| 159 | 0.91 | 0.53 | 57.87 |
| 160 | 1.47 | 1.25 | 84.83 |
| 161 | 0.62 | 0.45 | 72.57 |
| 162 | 0.46 | 0.25 | 53.53 |
| 163 | 0.47 | 0.24 | 50.81 |
| 164 | 0.46 | 0.09 | 20.53 |
| 165 | 0.60 | 0.07 | 11.15 |
| 166 | 0.63 | 0.10 | 15.76 |
| 167 | 0.45 | 0.42 | 93.74 |
| 168 | 0.46 | 0.46 | 99.44 |
| 169 | 0.68 | 0.04 | 5.18 |
| 170 | 0.65 | 0.19 | 28.66 |
| 171 | 0.79 | 0.20 | 25.37 |
| 172 | 0.80 | 0.10 | 12.74 |
| 173 | 0.54 | 0.13 | 24.38 |
| 174 | 0.34 | 0.09 | 25.03 |
| 175 | 0.64 | 0.16 | 25.02 |
| 176 | 0.49 | 0.13 | 25.68 |
| 177 | 0.49 | 0.13 | 25.86 |
| 178 | 0.49 | 0.13 | 26.43 |
| 179 | 0.54 | 0.09 | 16.96 |
| 180 | 0.66 | 0.06 | 9.18 |
| 181 | 0.46 | 0.46 | 101.03 |
| 182 | 0.46 | 0.46 | 100.91 |
| 183 | 0.46 | 0.46 | 100.93 |
| 184 | 0.46 | 0.42 | 92.07 |
| 185 | 0.46 | 0.26 | 56.80 |
| 186 | 0.47 | 0.46 | 98.89 |
| 187 | 0.42 | 0.42 | 100.14 |
| 188 | 0.42 | 0.42 | 100.65 |
| 189 | 0.89 | 0.89 | 100.40 |
| 190 | 2.03 | 1.02 | 50.26 |
| 191 | 0.71 | 0.57 | 80.34 |
| 192 | 0.60 | 0.60 | 100.53 |
| 193 | 0.80 | 0.78 | 97.84 |

| Parcel No. | Parcel Area (acres) | Alternative 4 Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 194 | 0.73 | 0.14 | 18.51 |
| 195 | 2.57 | 0.12 | 4.67 |
| 196 | 0.59 | 0.05 | 9.10 |
| 197 | 0.45 | 0.06 | 12.96 |
| 198 | 0.46 | 0.05 | 10.63 |
| 199 | 0.48 | 0.06 | 12.16 |
| 200 | 0.43 | 0.05 | 11.68 |
| 201 | 0.44 | 0.05 | 10.88 |
| 202 | 0.45 | 0.03 | 7.62 |
| 203 | 0.46 | 0.02 | 5.30 |
| 204 | 1.39 | 0.12 | 8.82 |
| 205 | 0.51 | 0.03 | 5.66 |
| 206 | 0.46 | 0.03 | 7.15 |
| 207 | 0.46 | 0.03 | 5.66 |
| 208 | 0.42 | 0.05 | 11.15 |
| 209 | 0.63 | 0.03 | 4.88 |
| 210 | 0.64 | 0.01 | 2.06 |
| 211 | 0.61 | 0.01 | 1.38 |
| 212 | 0.96 | 0.01 | 1.48 |
| 213 | 0.26 | 0.02 | 7.67 |
| 214 | 0.26 | 0.05 | 20.82 |
| 215 | 0.26 | 0.11 | 42.79 |
| 216 | 0.26 | 0.16 | 60.07 |
| 217 | 0.65 | 0.60 | 91.91 |
| 218 | 0.74 | 0.06 | 8.13 |
| 219 | 1.16 | 0.34 | 29.53 |
| 220 | 1.78 | 0.66 | 37.00 |
| 221 | 4.11 | 0.00 | 0.00 |
| 222 | 3.00 | 1.41 | 46.96 |
| 223 | 7.97 | 3.82 | 47.89 |
| 224 | 75.80 | 2.66 | 3.51 |
| 225 | 54.73 | 7.21 | 13.18 |
| 226 | 44.43 | 1.11 | 2.49 |
| 227 | 28.32 | 5.55 | 19.58 |
| 228 | 14.87 | 4.77 | 32.10 |
| 229 | 2.36 | 0.23 | 9.64 |

Parcel Area Source: National Land Cover Database (2006) (also see **Appendix R**)

### 4.7.4 Alternative 6

Construction, operation, and maintenance of Alternative 6 would permanently convert approximately xxx acres of land described as woody wetlands, cultivated crops, pasture/hay, mixed, evergreen, or deciduous forest, or open water land use to public water utility use. The percent change in land use in a parcel-by-parcel basis and total for Alternative 6 are summarized in **Table 4-21**. For Alternative 6, approximately 825 acres of land would be the minimum amount needed to construct and operate the proposed project. Alternative 6 in Harris County and Liberty County is located in areas without zoning regulations or restrictions. Land use in residential areas may be subject to deed restrictions and homeowner association requirements, although Alternative 6 area is relatively sparsely populated with limited residential development. Mineral, sand and gravel, hunting, agricultural and other leases may be associated with specific parcels within Alternative 6 ROW. There would be a direct, significant public benefit that would occur to change from private to public ownership of the 825 acres needed for the implementation of Alternative 6. The construction, operation, and maintenance of Alternative 6 would not affect or be impacted by land use controls or zoning.

**Table 4-21: Percentage Change of Land Use, Estimated Acreage and Percent Impact by Parcel Intersecting Alternative 6**

| Parcel No. | Parcel Area* (acres) | Alternative 6 Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 1 | 443.01 | 3.13 | 0.71 |
| 2 | 34.14 | 3.44 | 10.08 |
| 3 | 13.31 | 1.62 | 12.18 |
| 4 | 4.25 | 3.65 | 85.86 |
| 5 | 774.76 | 40.76 | 5.26 |
| 6 | 55.57 | 1.18 | 2.13 |
| 7 | 0.37 | 0.28 | 75.00 |
| 8 | 650.48 | 20.91 | 3.21 |
| 9 | 377.82 | 19.77 | 5.23 |
| 10 | 3,995.87 | 46.25 | 1.16 |
| 11 | 27.85 | 0.10 | 0.34 |
| 12 | 35.82 | 6.52 | 18.19 |
| 13 | 67.75 | 0.51 | 0.75 |
| 14 | 4.38 | 0.47 | 10.73 |
| 15 | 3.72 | 0.39 | 10.36 |
| 16 | 116.96 | 9.36 | 8.01 |
| 17 | 3,121.61 | 30.56 | 0.98 |
| 18 | 350.07 | 18.02 | 5.15 |
| 19 | 18.91 | 8.75 | 46.28 |
| 20 | 2.51 | 1.32 | 52.76 |
| 21 | 2.19 | 0.71 | 32.42 |
| 22 | 2.82 | 1.26 | 44.72 |
| 23 | 2.50 | 2.05 | 82.15 |
| 24 | 1.84 | 1.38 | 75.22 |
| 25 | 1.84 | 0.79 | 43.16 |
| 26 | 1.84 | 1.12 | 60.71 |
| 27 | 1.84 | 1.15 | 62.49 |
| 28 | 1.84 | 1.19 | 64.83 |
| 29 | 1.84 | 0.85 | 45.97 |
| 30 | 1.84 | 0.65 | 35.34 |
| 31 | 1.84 | 0.73 | 39.62 |
| 32 | 1.84 | 0.86 | 46.78 |
| 33 | 1.84 | 0.78 | 42.21 |
| 34 | 1.84 | 0.54 | 29.15 |
| 35 | 1.84 | 0.44 | 23.66 |
| 36 | 1.84 | 0.45 | 24.58 |
| 37 | 1.84 | 0.45 | 24.23 |
| 38 | 1.84 | 0.33 | 17.66 |
| 39 | 1.84 | 0.17 | 9.30 |
| 40 | 1.84 | 0.20 | 10.69 |
| 41 | 2.00 | 0.17 | 8.57 |
| 42 | 2.00 | 0.21 | 10.53 |
| 43 | 2.00 | 0.25 | 12.53 |
| 44 | 2.00 | 0.19 | 9.73 |

| Parcel No. | Parcel Area* (acres) | Alternative 6 Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 45 | 1.99 | 0.23 | 11.57 |
| 46 | 1.99 | 0.36 | 18.05 |
| 47 | 1.99 | 0.28 | 13.93 |
| 48 | 1.99 | 0.40 | 19.89 |
| 49 | 1.99 | 0.28 | 14.22 |
| 50 | 1.99 | 0.31 | 15.65 |
| 51 | 3.84 | 0.86 | 22.38 |
| 52 | 4.91 | 0.99 | 20.14 |
| 53 | 5.79 | 1.33 | 22.95 |
| 54 | 3.41 | 1.03 | 30.20 |
| 55 | 3.41 | 1.33 | 39.02 |
| 56 | 1.59 | 0.52 | 32.80 |
| 57 | 1.67 | 1.44 | 85.98 |
| 58 | 2.16 | 0.86 | 39.63 |
| 59 | 2.51 | 2.04 | 81.34 |
| 60 | 325.85 | 32.04 | 9.83 |
| 61 | 19.43 | 5.23 | 26.93 |
| 62 | 11.09 | 10.59 | 95.49 |
| 63 | 3.01 | 0.96 | 32.03 |
| 64 | 3.83 | 1.21 | 31.63 |
| 65 | 2.50 | 1.25 | 50.07 |
| 66 | 0.75 | 0.38 | 50.60 |
| 67 | 0.75 | 0.38 | 50.84 |
| 68 | 1.50 | 0.77 | 51.22 |
| 69 | 1.62 | 0.87 | 53.73 |
| 70 | 2.80 | 1.35 | 48.25 |
| 71 | 2.88 | 1.47 | 51.21 |
| 72 | 1.44 | 0.77 | 53.16 |
| 73 | 2.88 | 1.53 | 53.16 |
| 74 | 1.44 | 0.77 | 53.16 |
| 75 | 1.44 | 0.77 | 53.16 |
| 76 | 4.32 | 1.18 | 27.32 |
| 77 | 2.68 | 1.25 | 46.66 |
| 78 | 3.63 | 1.74 | 47.90 |
| 79 | 1.00 | 0.31 | 31.00 |
| 80 | 0.82 | 0.61 | 73.83 |
| 81 | 1.83 | 0.92 | 50.40 |
| 82 | 36.93 | 1.02 | 2.76 |
| 83 | 3.02 | 1.54 | 50.92 |
| 84 | 3.05 | 1.54 | 50.49 |
| 85 | 4.06 | 2.06 | 50.68 |
| 86 | 2.78 | 0.24 | 8.55 |
| 87 | 1.68 | 0.75 | 44.75 |
| 88 | 1.53 | 0.70 | 45.75 |
| 89 | 0.75 | 1.09 | 144.88 |
| 90 | 1.60 | 0.32 | 19.91 |
| 91 | 1.91 | 0.85 | 44.75 |
| 92 | 2.09 | 1.06 | 50.71 |
| 93 | 2.02 | 1.03 | 50.75 |
| 94 | 1.95 | 1.00 | 51.17 |
| 95 | 1.94 | 0.99 | 50.84 |
| 96 | 2.07 | 1.07 | 51.54 |
| 97 | 6.35 | 1.98 | 31.17 |
| 98 | 7.36 | 7.56 | 102.68 |
| 99 | 17.97 | 8.98 | 49.98 |
| 100 | 13.82 | 2.84 | 20.53 |
| 101 | 0.32 | 0.32 | 100.82 |
| 102 | 6.93 | 2.99 | 43.09 |

| Parcel No. | Parcel Area* (acres) | Alternative 6 Project Area (acres) | Percent Change of Land Use (Percent Impact) |
|---|---|---|---|
| 103 | 6.25 | 0.94 | 15.02 |
| 104 | 2.13 | 1.27 | 59.43 |
| 105 | 1.95 | 0.78 | 39.75 |
| 106 | 18.38 | 0.42 | 2.26 |
| 107 | 9.60 | 0.51 | 5.31 |
| 108 | 78.62 | 10.12 | 12.87 |
| 109 | 22.07 | 0.57 | 2.59 |
| 110 | 171.63 | 120.58 | 70.26 |
| 111 | 12.76 | 0.89 | 6.95 |
| 112 | 20.01 | 9.34 | 46.69 |
| 113 | 79.07 | 10.59 | 13.40 |
| 114 | 211.89 | 28.71 | 13.55 |
| 115 | 225.26 | 20.55 | 9.12 |
| 116 | 36.75 | 1.82 | 4.94 |
| 117 | 40.00 | 0.70 | 1.74 |
| 118 | 5.00 | 0.18 | 3.66 |
| 119 | 2.01 | 0.13 | 6.29 |
| 120 | 5.90 | 0.15 | 2.48 |
| 121 | 1.51 | 0.11 | 6.98 |
| 122 | 9.96 | 0.17 | 1.68 |
| 123 | 22.95 | 147.78 | 643.93 |
| 124 | 16.74 | 1.42 | 8.51 |
| 125 | 24.67 | 0.95 | 3.84 |
| 126 | 1.50 | 1.40 | 93.19 |
| 127 | 1.10 | 0.56 | 51.16 |
| 128 | 1.10 | 0.53 | 48.41 |
| 129 | 1.50 | 0.38 | 25.51 |
| 130 | 1.06 | 0.29 | 27.60 |
| 131 | 2.19 | 0.57 | 26.10 |
| 132 | 2.18 | 0.36 | 16.63 |
| 133 | 1.83 | 0.12 | 6.67 |
| 134 | 1.89 | 0.54 | 28.74 |
| 135 | 0.27 | 0.16 | 58.29 |
| 136 | 6.53 | 1.26 | 19.33 |
| 137 | 1.99 | 0.60 | 29.91 |
| 138 | 2.00 | 0.54 | 26.78 |
| 139 | 3.00 | 0.68 | 22.60 |
| 140 | 9.14 | 2.42 | 26.50 |
| 141 | 3.43 | 0.24 | 6.97 |
| 142 | 167.29 | 13.96 | 8.34 |
| 143 | 1,878.38 | 55.52 | 2.96 |
| 144 | 1.85 | 0.11 | 6.15 |
| 145 | 2.49 | 0.02 | 0.66 |
| 146 | 0.18 | 0.08 | 44.62 |
| 147 | 0.15 | 0.03 | 21.15 |
| 148 | 0.19 | 0.00 | 1.01 |
| 149 | 468.60 | 0.08 | 0.02 |
| 150 | 2.00 | 0.01 | 0.67 |
| 151 | 2.00 | 0.05 | 2.62 |
| 152 | 2.00 | 0.09 | 4.60 |
| 153 | 2.00 | 0.13 | 6.59 |
| 154 | 18.51 | 0.48 | 2.62 |
| 155 | 2.14 | 0.08 | 3.64 |
| 156 | 0.64 | 0.10 | 16.07 |

Parcel Area Source: National Land Cover Database (2006) (see also Appendix R)

## 4.7.5 Recreation and Parkland

The area of influence for recreation and parkland includes the potential location of right-of-way needed for the LBITP for all three action alternatives (Alternatives 3A, 4 and 6 ROW). The ROW would include including roads, pipeline easements, elevated canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines.

### 4.7.5.1 No Action

Under the No Action Alternative, there would be no direct or indirect impact to public parks, recreation areas, or public natural areas related to construction. Under No Action, the proposed 3,000 acre mitigation property would not be conveyed to the TRNWR for public use.

### 4.7.5.2 Alternative 3A

The proposed project would not directly impact public parks, recreation areas, or public natural areas. Alternative 3A ROW traverses along the southern boundary of May Park, a 70-acre facility with five lighted softball fields, one lighted football field, a small gazebo with four tables and a barbecue pit, picnic tables, two playgrounds, a splash pad, a paved walking trail, and restroom facilities. An increase in dust and noise caused by construction associated with Alternative 3A could temporarily impact park visitors. These construction impacts would be minimized through dust and noise control measures, such as, watering the disturbed ground within and along the project construction ROW to reduce dust emissions. The construction, operation, and maintenance of the proposed project would not directly impact public parks, recreation areas, or public natural areas.

The proposed compensatory mitigation property along the Trinity River floodplain would be conveyed to the USFWS to become part of the TRNWR and managed for public use. Management and long-term maintenance of the public use facility would be in accordance with the TRNWR Comprehensive Conservation Management Plan. There would be a long-term, direct, significant public benefit that would occur by the change from private to public ownership of the proposed mitigation property and land use controls for long-term maintenance and management.

One of the distinguishing characteristics of the LBITP area is the abundance of non-commercial navigational and recreational opportunities for tourists and residents. In addition, some residents live on property surrounding Lake Livingston and Lake Houston and aesthetics and water levels in the reservoirs are important. The following navigational and recreational activities are associated with water, both freshwater and salt water, and may be sensitive to water supply. Water supplies and recreation may be influenced by water levels in reservoirs, instream flows, bay and estuary inflows, water quality, habitat and aesthetics. **Table 4-22** lists recreational activities that are available to the residents and tourists and the ways in which those activities are sensitive to water supply. Although Lake Livingston, Lake Houston, and Lake Wallisville were built and are maintained for municipal and industrial water supply, their existence has spurred the development of recreation related economic activity. Recreation-oriented development expands the tax base of local jurisdictions located near the reservoirs.

**Table 4-22:**
**Activities Associated with Surface Water Supply Sources**

| Activity | Water Supply Sensitivities |
|---|---|
| Boating including the use of canoe/kayaks, sailboats, personal watercraft, power boats | Reservoir levels<br>Instream flow<br>Aesthetics |
| Swimming | Aesthetics<br>Water quality<br>Reservoir level<br>Instream flows |
| Fishing | Reservoir levels<br>Instream flow |

| Activity | Water Supply Sensitivities |
|---|---|
| | Bay and estuary inflows<br>Water quality<br>Habitat |
| Hunting | Habitat<br>Instream flow |
| Parks including areas that allow camping, hiking, biking, and horseback riding | Aesthetics<br>Habitat<br>Instream flow |
| Nature Tourism | Reservoir level<br>Instream flow<br>Bay & Estuary inflows<br>Habitat<br>Aesthetics |

These activities impact the economy of the region and the socioeconomic analysis of water shortages would include loss of potential revenue related to such items as the sale of boating equipment, pier use fees, hunting and fishing fees, hotel and restaurant receipts. The determination of a direct relationship between water management strategies and recreational opportunities and indirect economic impacts is not feasible, due to the numerous other factors that affect recreational economics (i.e., weather conditions, national economic conditions, travel restrictions, etc.). However, the collective affects of strategies on anticipated lake levels during historical meteorological conditions were analyzed and some conclusions may be inferred on the impacts to recreation and economics.

## 4.7.6 Agriculture

The proposed LBITP poses significant effects to farmlands from a physical standpoint (land loss), from an income generation perspective, and from a tax revenue loss standpoint. A detailed analysis was developed for each alternative for farm income to producers foregone and tax revenue foregone (Holloway 2012). Farm income also includes timber production income. The results indicate that adverse impacts to farm and agricultural income associated with Alternative 3A, 4, and 6 may occur and are itemized in more detail below.

### 4.7.6.1 No Action

The area directly influenced by the LBITP for agriculture includes the potential location for the proposed project including access roads, pipelines and easements, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines.

### 4.7.6.2 Alternative 3A

Farmland areas within the vicinity of the proposed Alternative 3A have been identified. Alternative 3A traverses through approximately 9.5 miles of farmland resources that would be permanently converted to public use from agriculture. It would be anticipated that agricultural leases would remain active until immediately prior to construction of Alternative 3A to maximize agricultural production and minimize impact to food and fiber production.

Currently, the water used in rural (livestock) and agricultural areas represent 13 percent of the total water used in Region H, a decline from 22% estimated in the year 2000. It is estimated that this will be reduced to 12% of the Region’s 3,525,100 acre-feet demand projected in year 2060, mainly due to the growth of municipal and industrial demands. There is a slight projected decrease in irrigation (from 450,175 acre-feet per year in 2010 to 430,930 acre-feet per year in 2060, or a net reduction of 4 percent). Livestock demand is constant over the planning period. Water management strategies, along with current sources of reliable water supply and interruptible supplies, are available to agricultural users; as a result, the impacts on agricultural users are not directly related to moving water from these areas.

The relationship between land value and the potential income that can be generated from it is expressed as a capitalization rate, which is the rate of return on a real estate investment based on the expected net income that the property would generate. This rate would be determined by dividing the income the property would generate by the total value of the property after fixed costs and variable costs have been deducted and are one of the many factors used by county appraisers to value agricultural land and timberlands. Other factors affecting the final productivity values include local agricultural trends, income and expense information, property characteristics and the property's particular agricultural use.

The valuation of agricultural and timberland in Texas is determined by capitalizing the average net income the land would have yielded under prudent management from production of agricultural or timber products during the five years preceding the current year. To determine productivity values, county appraisers calculate the typical property owner's income generated by the land and subtract expenses. The result is commonly known as net-to-land, or the return to the landowner for his efforts. County appraisers then divide the average net-to-land for a five-year period by the State's prescribed annual capitalization rate to derive the land's assessed value. This productivity value is reported as the parcel's agricultural or timber use value and becomes the basis upon which taxes are then levied. In 2011, the capitalization rate was set at ten percent for agricultural and open space land and 8.72 percent for timberland by the Texas State Comptroller's Property Tax Assistance Division. [17]

By understanding this methodology, it is possible to deduce the net-to-land value by reversing application of the capitalization rate. In order to estimate the impact to agricultural and timber productivity, the 2011 assessed agricultural and timber use values assigned to affected parcels were multiplied by their respective 2011 capitalization rates to derive an estimate of the average net income to producers. The percentage of income that would be foregone if the land were converted to public use ROW was estimated by applying the simplifying assumption of uniform value within the parcel. While this method is imprecise as to a specific parcel with regard to definitive impact, it does provide a general estimate of magnitude of impact with regard to expected loss of net income to property owners. The estimated average yearly net income from agricultural or timber production potentially available to land owners for the properties that intersect the Alternative 3A alignment:

- Harris County—$19,079
- Liberty County—$133,568

For the property directly affected by proposed Alternative 3A ROW, the approximate net income losses to producers were estimated using a method that determined the productive value of land based on county appraisal records. Each appraisal district assigns value to properties within their respective counties that form the assessments from which taxing entities levy taxes and derive revenues. Qualified agricultural land, open-space, and timberland in Texas are assessed on their productive value rather than the market value. This value is based solely on the land's capacity to produce agricultural products, such as livestock, cotton, timber, milk and corn.[1] The intention is for landowners to realize property tax savings while encouraging the production of vital agricultural products necessary to support the general welfare of the population. The direction to appraise agricultural and timberland based on its productivity stems from State law found under Title 1, Property Tax Code, Chapter 23, Subchapters C, D, and E.[2] Uniform procedures are promulgated in the Manual for the Appraisal of Timberland[3] and Manual for the Appraisal

1 http://www.cpa.state.tx.us/taxinfo/proptax/caprates.html

2 *Tax Code, Title 1. Property Tax Code*, Subtitle D. Appraisal and Assessment, Chapter 23. Appraisal Methods and Procedures, *http://www.statutes.legis.state.tx.us/Docs/TX/htm/TX.23.htm*

3 Carole Keeton Strayhorn, Texas Comptroller, *Texas Property Tax, Manual for the Appraisal of Timberland*, May 2004

of Agricultural Land[4] developed by the Texas State Comptroller of Public Accounts. The extent of the effect on agricultural and timber production would be determined by the conveyance route considered and the extent to which property parcels along each route possess productive value. To evaluate these effects, the productive value of the land was developed by assuming that the percentage of the affected parcel's productive value equals the percentage of the total area of the parcel dedicated to the proposed ROW.

The extent of the effect on agricultural and timber production would be determined by the conveyance route considered and the extent to which property parcels along each route possess productive value. To evaluate these effects, the productive value of the land was developed by assuming that the percentage of the affected parcel's productive value equals the percentage of the total area of the parcel dedicated to the proposed ROW.

More than 4,000 acres of property affecting all or part of 54 parcels of land in Liberty and Harris Counties would be acquired for Alternative 3A. These acres would be removed from the tax rolls and the change of land use from private to public would result in a decrease in property tax revenue for Harris and Liberty Counties, Texas, excluding the approximate 3,000 acre proposed mitigation property that was acquired by Coastal Water Authority (at a cost of approximately $17 million). The anticipated construction costs of Alternative 3A are estimated at $228 million in 2014 dollars (see also **Chapter 2.8.17**). The loss of total yearly net income to producers from the loss of property production (including food, fiber, and timber) is estimated at $7,130 for Liberty County producers and $1,652 for Harris County producers for a total of $8,782 for Alternative 3A (or a 5.8 percent loss of total yearly net income to producers). The loss of foregone annual tax revenue for Alternative 3A (representing the change from private to public land) is estimated at $6,015 (Holloway 2012). These two cost estimates do not include the loss of net income to producers and the loss of tax revenues for the 3,000 acre proposed mitigation property in Liberty County.

##### 4.7.6.2.1 Alternative 4

Approximately 1,000 acres of property affecting portions of 228 parcels of land that would be acquired for Alternative 4 at a cost estimated at approximately $6.6 million (Kottke 2012), excluding the cost of the mitigation property that was acquired by the Coastal Water Authority at a cost of approximately $17 million. The anticipated construction costs of Alternative 4 are estimated at $595 million in 2014 dollars (see also **Chapter 2.8.17**). These properties would also be removed from the tax rolls, creating a decrease in property tax revenue for Harris and Liberty Counties, Texas, excluding the approximate 3,000 acre proposed mitigation property. Construction costs of Alternative 4 are estimated at $561 million in 2014 dollars.

The loss of total yearly net income to producers from the loss of property production (including food, fiber, and timber) is estimated at $619 for Liberty County producers and $1,696 for Harris County producers for a total of $2,315 or less than 2.5 percent loss to yearly net income forgone to producers. Alternative 4 pose significant effects from a tax revenue loss standpoint because the annual tax revenue losses for Alternative 4 are estimated at $125,000. These two cost estimates do not include the loss of net income to producers and the loss of tax revenues for the approximate 3,000 acre proposed mitigation property in Liberty County.

Less than approximately 725 acres of property in 156 parcels of land would be acquired for Alternative 6 at a cost estimated at approximately $4.18 million (Kottke 2012), excluding the cost of the mitigation property that was acquired by the Coastal Water Authority at a cost of approximately $17 million. These properties would also be removed from the tax rolls, creating a decrease in property tax revenue for Harris and Liberty Counties, Texas, excluding the approximate 3,000 acre proposed mitigation property. Construction costs of Alternative 6 are estimated at $494 million in 2014 dollars (see also **Chapter 2.8.17**).

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4 Texas State Comptroller of Public Accounts, *Texas Property Tax, Manual for the Appraisal of Agricultural Land*, Office of the Comptroller, Texas, April 1990.

The loss of total yearly net income to producers from the loss of property production (including food, fiber, and timber) is estimated at $19,372 for Liberty County producers and $2,694 for Harris County producers for a total of $22,066 or a 24.2 percent loss to yearly net income foregone to producers. This percentage reflects the total yearly net income to producers foregone with ROW acquisition and use for public water supply. Foregone annual tax revenue losses for Alternative 6 would be $227,391.

## 4.7.7 Housing and Residential Development

The area directly influenced by the proposed project and alternatives with respect to housing and residential development includes the proposed location for the project ROWs including roads, pipeline, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines.

### 4.7.7.1 Alternative 3A

Areas targeted or with existing residential development within the vicinity of the proposed Alternative 3A have been identified although Alternative 3A would not impact or displace residential development. However, one resident may be displaced depending on the resolution of a cell tower relocation alternative.

Three different alignment alternatives were considered for the Alternative 3A ROW in the vicinity of Parcel 50 due to residential development concerns. The initial alignment in this area divided Parcel 50 in an east-west direction. An initial evaluation of the proposed alignment identified the need for a bridge to provide access across the proposed canal conveyance in this area. A second alignment alternative was also considered to avoid a 50 foot wide Harris County Flood Control District (HCFCD) ditch and easement. Finally, a third alternative provided a canal alignment along the southern boundary of Parcel 50 minimizing potential environmental consequences to residential properties. This third alternative increased overall project length and resultant cost for construction as well as encroaching on the mapped Cedar Bayou flood hazard area; however, the environmental consequences related to residential development was minimized and environmental consequences of affecting the HCFCD flood control ditch easement were avoided.

The project would predominantly traverse undeveloped land. The project does not isolate communities. Alternative 3A would discharge into Lake Houston near the confluence with Luce Bayou. Alternative 3A would not isolate homes or create a physical barrier within a community. There would be no impacts on housing or community cohesion as a result of the implementation of Alternative 3A.

Construction, operation, and maintenance of Alternative 3A would permanently and directly impact more than 1,050 acres of land described as woody wetlands, cultivated crops, pasture/hay, mixed, evergreen or deciduous forest, or open water land use to public water utility use. The percent change in land use in a parcel-by-parcel basis for Alternative 3A is summarized above (**Table 4-19**). For Alternative 3A, approximately 1,050 acres of land would be the minimum amount needed to construct and operate the proposed project. Alternative 3A in Harris County and Liberty County is located in areas without zoning regulations or restrictions. Land use in residential areas may be subject to deed restrictions and homeowner association requirements, although Alternative 3A area is relatively sparsely populated with limited residential development. Mineral, sand and gravel, hunting, agricultural and other leases may be associated with specific parcels within Alternative 3A ROW. There would be a direct, significant public benefit that would occur to change from private to public ownership of the 1,050 acres needed for the implementation of Alternative 3A. The construction, operation, and maintenance of Alternative 3A would not affect or be impacted by land use controls or zoning.

#### 4.7.7.2 Alternative 4

Construction, operation, and maintenance of Alternative 4 would permanently convert approximately 885 acres of land described as woody wetlands, cultivated crops, pasture/hay, mixed, evergreen, or deciduous forest, or open water land use to public water utility use. The percent change in land use in a parcel-by-parcel basis for Alternative 4 is summarized in **Table 4-20**.

For Alternative 4, approximately 885 acres of land would be the minimum amount needed to construct and operate the proposed project. Alternative 4 in Harris County and Liberty County is located in areas without zoning regulations or restrictions. Land use in residential areas may be subject to deed restrictions and homeowner association requirements, although Alternative 4 area is relatively sparsely populated with limited residential development. Mineral, sand and gravel, hunting, agricultural and other leases may be associated with specific parcels within Alternative 4 ROW. There would be a direct, significant public benefit that would occur to change from private to public ownership of the 885 acres needed for the implementation of Alternative 4. The construction, operation, and maintenance of Alternative 4 would not affect or be impacted by land use controls or zoning.

The property sizes by parcel number, land use, displacements and right-of-way acquisition costs for Alternative 4 are summarized in **Table 4-20** located in **Appendix R**. The market values provided in the table were based on review of data provided by Harris County Appraisal District (HCAD) and Liberty County Central Appraisal District (LCAD). Calculations for the right-of-way acquisition costs were based on the best available data from these two sources. The types of structures (residential or commercial) within the right-of-way were determined by reviewing USDA aerial imagery (USDA NAIP Texas 2010) and data from HCAD and LCAD. Within Alternative 4, 69 parcels, or 30 of the total parcels, have displacements. Of those displacements, 63 are residential.

#### 4.7.7.3 Alternative 6

Construction, operation, and maintenance of Alternative 6 would permanently convert approximately 725 acres of land described as woody wetlands, cultivated crops, pasture/hay, mixed, evergreen, or deciduous forest, or open water land use to public water utility use. The percent change in land use in a parcel-by-parcel basis for Alternative 6 is summarized in **Table 4-21**. For Alternative 725 acres of land would be the minimum amount needed to construct and operate the proposed project. Alternative 6 in Harris County and Liberty County is located in areas without zoning regulations or restrictions. Land use in residential areas may be subject to deed restrictions and homeowner association requirements, although Alternative 6 area is relatively sparsely populated with limited residential development. Mineral, sand and gravel, hunting, agricultural and other leases may be associated with specific parcels within Alternative 6 ROW. There would be a direct, significant public benefit that would occur to change from private to public ownership of the 725 acres needed for the implementation of Alternative 6. The construction, operation, and maintenance of Alternative 6 would not affect or be impacted by land use controls or zoning.

The property sizes by parcel number, land use, displacements and right-of-way acquisition costs for Alternative 6 are summarized in **Table 4-21** and in **Appendix R**. The market values provided in the table were based on review of data provided by Harris County Appraisal District (HCAD) and Liberty County Central Appraisal District (LCAD). Calculations for the right-of-way acquisition costs were based on the best available data from these two sources. The types of structures (residential or commercial) within the right-of-way were determined by reviewing USDA aerial imagery (USDA NAIP Texas 2010) and data from HCAD and LCAD. Within Alternative 6, 48 parcels, or 31 of the total parcels, have displacements. Of those displacements, 36 are residential.

#### 4.7.7.4 Mitigation

The proposed Alternative 3A ROW follows the property lines of residential properties to minimize affects to residences and future development.

## 4.7.8 Mining and Underground Natural Gas Storage

For any build alternative, a potential exists for impacts to oil and gas facilities within the proposed project corridors. Major impacts to mining and underground natural gas storage in the area are not anticipated. In general, impacts to local oil and gas fields would be limited in magnitude, but would possibly require relocating or removing oil and gas facilities. After the ROW has been purchased, construction is anticipated to cause short-term impacts if existing oil and gas facilities need to be relocated or removed. If a surface well is in an excavation area and the well must be removed, any residual petroleum project may need remediation efforts over an extended period. The estimated number of oil and gas facilities in the project corridor is discussed below. A Phase I and Phase II Environmental Site Assessment would be needed to address the impact's extent from existing oil and gas facilities in the project area.

### 4.7.8.1 No Action

Under the No Action Alternative, the proposed project would not be built and privately-owned property, potential gas field development, and the planned Houston ENSTOR HUB Storage Project would not be affected by project-related construction, operation, or maintenance activities.

### 4.7.8.2 Alternative 3A

Areas targeted with or having existing mineral and natural resource development within the proposed Alternative 3A's vicinity have been identified. One new gas well about 500 feet west of Alternative 3A is named the Gordy No.1 Holmes well. The Gordy No.1 Holmes well site construction had not yet commenced when this document was developed. This gas well's discovery could potentially lead to other well discoveries within Alternative 3A ROW's vicinity. Coordination with the Gordy Oil Company should be conducted to discuss the proposed Alternative 3A ROW and future potential gas field development.

The planned Houston HUB Storage Project development by ENSTOR could potentially impact the Alternative 3A ROW at the north end, where the NGPL Interconnect/Meter site adjoins Parcels 23.2 (Stilson Properties Inc., 000176 J. Darwin Tract 4) and Parcel 25.6 (Carolyn Epple Johnson and Riceland Properties Inc. 000485 Ed Pruitt-122, Tract 1). Coordination with ENSTOR should be conducted to discuss the proposed Alternative 3A ROW and future potential Houston HUB Storage Project.

### 4.7.8.3 Alternative 4

Areas targeted with or having existing mineral and natural resource development within the proposed Alternative 3A's vicinity have been identified. Five oil and gas well locations are within the proposed 300-foot project corridor for Alternative 4. According the RRC records, three oil and gas sites are documented dry holes, one site is a directional well surface site and one site is an oil well. Site completion or plugging was only documented for the directional well surface site and one dry well. This gas well's discovery could potentially lead to other well discoveries within Alternative 3A ROW's vicinity. Coordination with the oil companies would be conducted to discuss future potential gas field development and possible oil and gas facility removal or relocation.

### 4.7.8.4 Alternative 6

Areas targeted with or having existing mineral and natural resource development within the proposed Alternative 6 vicinity have been identified. Six oil and gas well locations are within the proposed 300-foot project corridor for Alternative 4. Four sites are documented oil wells; the other two are a dry well and permitted location. Three oil wells are either marked as completed or plugged, and the dry hole is plugged, according the RRC records. Coordination with the oil company should be conducted to discuss the proposed Alternative 6 ROW and future potential gas field development and/or possibly removing or relocating these oil and gas facilities.

### 4.7.9 Energy and Mineral Resources

#### 4.7.9.1 Alternative 3A

After the ROW has been purchased, construction is anticipated to cause short-term impacts if existing oil and gas facilities need to be relocated or removed. If the surface completion of a productive oil and gas well must be removed, any residual petroleum project may need remediation efforts over an extended period.

#### 4.7.9.2 Alternative 4

After the ROW has been purchased, construction is anticipated to cause short-term impacts if existing oil and gas facilities need to be relocated or removed. If the surface completion of a productive oil and gas well must be removed, any residual petroleum project may need remediation efforts over an extended period.

#### 4.7.9.3 Alternative 6

After the ROW has been purchased, construction is anticipated to cause short-term impacts if existing oil and gas facilities need to be relocated or removed. If the surface completion of a productive oil and gas well must be removed, any residual petroleum project may need remediation efforts over an extended period.

### 4.7.10 Socioeconomic Issues

Economic analysis as it relates to water resources planning generally falls into two broad areas. Supply side analysis focuses on costs and alternatives for developing new water supplies or implementing programs that provide additional water from current supplies. Demand side analysis concentrates on impacts or benefits from providing water to people, businesses and the environment.

Employment, income, and business taxes are the most useful variables when comparing an economic sector's relative contribution to a regional economy. Direct impacts accrue to immediate businesses and industries that rely on water and without water industrial processes could suffer. However, output responses may vary depending on the shortages' severity. A small shortage relative to total water use would likely have a minimal impact, but large shortages could be critical. For example, farmers facing small shortages may fallow marginally productive acreage to save water for more valuable crops. Livestock producers may employ emergency culling strategies, or consider hauling water by truck to fill stock tanks. A good manufacturing example occurred in the summer of 1999 when Toyota Motor Manufacturing experienced water shortages at a facility near Georgetown, Kentucky.[5] As water levels in the Kentucky River fell to historic lows due to drought, plant managers sought ways to curtail water use such as reducing rinse operations to a bare minimum and recycling water by funneling it from paint shops to boilers. They even considered trucking in water at a cost of 10 times what they were paying. Fortunately, rains at the end of the summer restored river levels, and Toyota managed to implement cutbacks without affecting production, but it was a close call. If rains had not replenished the river, shortages could have severely reduced output.[6]

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5 Royal, W. "High And Dry - Industrial Centers Face Water Shortages." in Industry Week, Sept, 2000.

6 The efforts described above are not planned programmatic or long-term operational changes. They are emergency measures that individuals might pursue to alleviate what they consider a temporary condition. Thus, they are not characteristic of long-term management strategies designed to ensure more dependable water supplies such as capital investments in conservation technology or development of new water supplies.

To account for uncertainty regarding the relative magnitude of impacts to farm and business operations, the following analysis employs the elasticity concept. Elasticity is a number showing how a change in one variable will affect another. It measures the relationship between a percentage reduction in water availability and a percentage reduction in output. For example, an elasticity of 1.0 indicates a 1.0 percent reduction in water availability would result in a 1.0 percent reduction in economic output. An elasticity of 0.50 would indicate that for every 1.0 percent of unavailable water, output is reduced by 0.50 percent, and so on. Output elasticities used in this study are:[7]

- if water needs are 0 to 5 percent of total water demand, no corresponding reduction in output is assumed;
- if water needs are 5 to 30 percent of total water demand, for each additional one percent of water need not met, there is a corresponding 0.50 percent reduction in output;
- if water needs are 30 to 50 percent of total water demand, for each additional one percent of water need not met, there is a corresponding 0.75 percent reduction in output; and
- if water needs are greater than 50 percent of total water demand, for each additional one percent of water need not met, there is a corresponding 1.0 percent (i.e., a proportional reduction).

In some cases, elasticities are adjusted depending on conditions specific to a given water user group.

#### 4.7.10.1 Agriculture

The following steps outline the overall process used to estimate direct impacts to irrigated agriculture.

- *Distribute shortages across predominant crop types in the region*. Unmet water needs were distributed equally across crop sectors that constitute one percent or more of irrigated acreage.

- *Estimate associated reductions in output for affected crop sectors*. Output reductions are based on elasticities, discussed previously, and on estimated values per acre for different crops. Values per acre stem from the same data used to estimate output for the year 2006 baseline. Using multipliers, we generate estimates for decreased income, jobs, and tax revenues based on reductions in gross sales and final demand.

- *Reduce sales revenues for forward processers in proportion to lost rice production*. Input output models capture indirect losses to suppliers and other businesses that depend on rice farming, but only those providing inputs to rice production. Multipliers do not capture potential impacts to forward processors, in this case rice mills, which add considerable value to the product and hence income and jobs to the state. For example, Texas rice farming directly generates about $60 to $80 in gross state product. Once the harvested, the rice is sold to rice mills that process and resell the crop. This added value generates an additional $60 to $80 million in direct gross state product.

The approach used for the livestock sector is basically the same as that used for crop production.

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7 Elasticities are based on one of the few empirical studies that analyze potential relationships between economic output and water shortages in the United States. The study, conducted in California, showed that a significant number of industries would suffer reduced output during water shortages. Using a survey based approach researchers posed two scenarios to different industries. In the first scenario, they asked how a 15 percent cutback in water supply lasting one year would affect operations. In the second scenario, they asked how a 30 percent reduction lasting one year would affect plant operations. In the case of a 15 percent shortage, reported output elasticities ranged from 0.00 to 0.76 with an average value of 0.25. For a 30 percent shortage, elasticities ranged from 0.00 to 1.39 with average of 0.47. For further information, see, California Urban Water Agencies, “Cost of Industrial Water Shortages,” Spectrum Economics, Inc. November, 1991.

- *Distribute projected water needs equally among predominant livestock sectors and estimate lost output*: As is the case with irrigation, shortages are assumed to affect all livestock sectors equally. If water needs were small relative to total demands, we assume producers would haul in water by truck to fill stock tanks. The cost per acre-foot ($24,000) is based on 2008 rates charged by various water haulers in Texas, and assumes the average truck load is 6,500 gallons at a hauling distance of 60 miles.

- *Estimate reduced output in forward processors for livestock sectors*. Reductions in output for livestock sectors are assumed to have a proportional impact on forward processors in the region such as meat packers. If the cows were gone, meat-packing plants or fluid milk manufacturers) would likely have little to process. This is not an unreasonable premise. Since the 1950s, there has been a major trend towards specialized cattle feedlots, which in turn has decentralized cattle purchasing from livestock terminal markets to direct sales between producers and slaughterhouses. Today, the meat packing industry often operates large processing facilities near high concentrations of feedlots to increase capacity utilization.[8] As a result, packers heavily depend on nearby feedlots. For example, a recent USDA study shows on average meat packers obtain 64 percent of cattle from within 75 miles of their plant, 82 percent from within 150 miles and 92 percent from within 250 miles.[9]

### 4.7.10.2 Domestic Water Uses

The economic impact per acre-foot of domestic water needs for municipal water user groups with population exceeding 100,000 people has been developed. Several important assumptions are incorporated into these calculations.

- Reported values are net of the treatment and distribution variable costs such as expenses for chemicals and electricity, since using less water involves some savings to consumers and utilities alike; and for outdoor uses we do not include any value for wastewater.
- Outdoor and non-essential water uses would be eliminated before indoor water consumption was affected, which is logical because most water utilities in Texas have drought contingency plans that generally specify curtailing or eliminating outdoor water use during droughts.[10] Determining how much water is used for outdoor purposes is based on several secondary sources. The first is a major study sponsored by the American Water Works Association, which surveyed cities in states including Colorado, Oregon, Washington, California, Florida and Arizona. On average across all cities surveyed, 58 percent of single-family residential water use was for outdoor activities. In cities with climates comparable to large Texas metropolitan areas, the average was 40 percent.[11] Earlier U.S. Water Resources Council findings showed a 33 percent national average. Similarly, the USEPA estimated landscape watering accounts for 32 percent of total residential and commercial water use on annual basis.[12] A study conducted for the California Urban Water Agencies calculated average annual values

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8 Ferreira, W.N. "*Analysis of the Meat Processing Industry in the United States*." Clemson University Extension Economics Report ER211, January 2003.

9 Ward, C.E. "*Summary of Results from USDA's Meatpacking Concentration Study*." Oklahoma Cooperative Extension Service, OSU Extension Facts WF-562.

10 In Texas, state law requires retail and wholesale water providers to prepare and submit plans to the Texas Commission on Environmental Quality (TCEQ). Plans must specify demand management measures for use during drought including curtailment of "non-essential water uses." Non-essential uses include, but are not limited to, landscape irrigation and water for swimming pools or fountains. For further information see the Texas Environmental Quality Code §288.20.

11 See, Mayer, P.W., DeOreo, W.B., Opitz, E.M., Kiefer, J.C., Davis, W., Dziegielewski, D., Nelson, J.O. "*Residential End Uses of Water*." Research sponsored by the American Water Works Association and completed by Aquacraft, Inc. and Planning and Management Consultants, Ltd. (PMCL@CDM).

12 U.S. Environmental Protection Agency. *"Cleaner Water through Conservation*." USEPA Report no. 841-B-95-002. April, 1995.

ranging from 25 to 35 percent.[13] Unfortunately, no comprehensive research appears to have estimated non-agricultural outdoor water use in Texas. As an approximation, an 30 percent average annual value based on the above references was selected to serve as a rough estimate in this study.

- As shortages approach 100 percent, values become immense and theoretically infinite. At 100 percent death would result, and willingness to pay for water is immeasurable. Thus, as shortages approach 80 percent of monthly consumption, we assume households and non-water intensive commercial businesses who use water only for drinking and sanitation would have water delivered by tanker truck or commercial water delivery companies. Based on reports from water companies throughout the state, we estimate the cost for trucking in water is around $21,000 to $27,000 per acre-foot, assuming a hauling distance between 20 to 60 miles. This is not an unreasonable assumption. The practice was widespread during the 1950s drought and recently during droughts in this decade. For example, in 2000 at the heels of three consecutive drought years, Electra—a small town in North Texas—was down to its last 45-days of reservoir water when rain replenished the lake, and the city was able to refurbish old wells to provide supplemental groundwater. At the time, residents were forced to limit water use to 1,000 gallons per person per month—less than half what most people use—and many were having water delivered to their homes by private contractors.[14]

- In 2003, citizens of Ballinger, Texas were faced with a dwindling water supply due to prolonged drought. After three years of drought, Lake Ballinger, which supplies water to more than 4,300 residents in Ballinger and to 600 residents in nearby Rowena, was almost dry. Each day, people lined up to get water from a well in nearby City Park. Trucks with trailers outfitted with large plastic and metal tanks hauled water to and from City Park to Ballinger.[15]

#### 4.7.10.3 Commercial Businesses

Effects from water shortages on commercial sectors were estimated in a fashion similar to other business sectors, which means water shortages would affect the ability of these businesses to operate. This is particularly true for water intensive commercial sectors needing large amounts of water (in addition to potable and sanitary water) to provide their services. These include:

- Beverage manufacturers,
- Car-washes,
- Laundry and cleaning facilities,
- Sports and recreation clubs and facilities including race tracks,
- Amusement and recreation services,
- Hospitals and medical facilities,
- Hotels and lodging places, and
- Eating and drinking establishments.

A key assumption is that commercial operations would not be affected until water shortages were at least 50 percent of total municipal demand. In other words, we assume residential water consumers would reduce water use including all non-essential uses before businesses were affected.

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13 Planning and Management Consultants, Ltd. “*Evaluating Urban Water Conservation Programs: A Procedures Manual*.” Prepared for the California Urban Water Agencies. February 1992.

14 Zewe, C. “*Tap Threatens to Run Dry in Texas Town*.” July 11, 2000. CNN Cable News Network.

15 Associated Press, “*Ballinger Scrambles to Finish Pipeline before Lake Dries Up*.” May 19, 2003.

### 4.7.10.4 Other Areas

Three other areas were considered when analyzing municipal water shortages: 1) lost revenues to water utilities, 2) losses to the horticultural and landscaping industries stemming from reduction in water available for landscape irrigation, and 3) lost revenues and related economic impacts associated with reduced water related recreation.

### 4.7.10.5 Water Utility Revenues

Estimating lost water utility revenues was straightforward. Annual data from the *Water and Wastewater Rate Survey* published annually by the Texas Municipal League were used to calculate an average value per acre-foot for water and sewer. For water revenues, average retail water and sewer rates multiplied by total water needs served as a proxy. For lost wastewater, total unmet needs were adjusted for return flow factor of 0.60 and multiplied by average sewer rates for the region. Needs reported as county-other were excluded under the presumption these consist primarily of self-supplied water uses. In addition, 15 percent of water demand and needs are considered non-billed or unaccountable water that comprises things such as leaks and water for municipal government functions (e.g., fire departments). Lost tax receipts are based on current rates for the miscellaneous gross receipts tax, which the state collects from utilities located in most incorporated cities or towns in Texas. We do not include lost water utility revenues when aggregating impacts from municipal water shortages to regional and state levels to prevent double counting.

### 4.7.10.6 Horticultural and Landscaping Industry

The horticultural and landscaping industry, also referred to as the green Industry, includes businesses that produce, distribute, and provide services associated with ornamental plants, landscape and garden supplies and equipment. Horticultural industries often face big losses during drought. For example, horticultural and landscaping businesses in the Southeast during the recent drought affecting the Carolinas and Georgia had a harsh year. Plant sales were down, plant mortality increased and watering costs soared. Many businesses were forced to close locations, lay off employees and some even file for bankruptcy. University of Georgia economists put statewide industry losses at around $3.2 billion during the 3-year drought that ended in 2008.[16] Municipal restrictions on outdoor watering played a significant role. During droughts, water restrictions coupled with persistent heat have a psychological effect on homeowners that reduces demands for landscaping products and services. Residents are afraid to spend any money on new plants and landscaping during drought periods.

In Texas, no readily available studies analyze the economic effects from water shortages on the landscaping industry. However, authors of this report believe negative impacts do and would result in restricting landscape irrigation to municipal water consumers. The difficulty in measuring them is two-fold. First, as noted above, data and research for these types of impacts that focus on Texas are limited; and second, economic data provided by IMPLAN do not disaggregate different sectors of the green industry to a level that would allow for meaningful and defensible analysis.[17]

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16 Williams, D. *"Georgia landscapers eye rebound from Southeast drought."* Atlanta Business Chronicle, Friday, June 19, 2009

17 Economic impact analyses prepared by the TWDB for 2006 regional water plans did include estimates for the horticultural industry. However, year 2000 and prior IMPLAN data were disaggregated to a finer level. In the current dataset (2006), the sector previously listed as "Landscaping and Horticultural Services" (IMPLAN Sector 27) is aggregated into "Services to Buildings and Dwellings" (IMPLAN Sector 458).

Recreational businesses often suffer when water levels and flows in rivers, springs and reservoirs fall significantly during drought, and many boat docks and lake beaches are forced to close. This leads to big losses for lakeside business owners and local communities. Communities adjacent to popular river and stream destinations such as Comal Springs and the Guadalupe River also see their business plummet when springs and rivers dry up. Although there are many examples of businesses that have suffered due to drought, dollar figures for drought-related losses to the recreation and tourism industry are not readily available, and are very difficult to measure without extensive local surveys. Thus, while they are important, economic impacts are not measured in this study.

#### 4.7.10.7 Industrial Water User Groups

Impacts to manufacturing were estimated by distributing water shortages among industrial sectors at the county level.

#### 4.7.10.8 Mining

In Texas, oil and gas extraction and sand and gravel (aggregates) operations are the primary mining industries that rely on large water volumes. For sand and gravel, estimated output reductions are straightforward; however, oil and gas is more complicated for a number of reasons. Model results would not necessarily address the physical extraction of minerals by geographic local, but rather the sales revenues reported by a particular corporation. Petroleum and gas extraction industry only used water in significant amounts for secondary recovery. Known in the industry as enhanced or water flood extraction, secondary recovery involves pumping water down injection wells to increase underground pressure thereby pushing oil or gas into other wells. Recent activities in extracting oil and gas from the Eagle Ford and Barnett Shale plays would not affect Region H RWP strategies.

#### 4.7.10.9 Steam-electric

At minimum without adequate cooling water, power plants cannot safely operate. As water availability falls below projected demands, water levels in lakes and rivers that provide cooling water would also decline. Low water levels could affect raw water intakes and outfalls at electrical generating units in several ways. For one, power plants are regulated by thermal emission guidelines that specify the maximum amount of heat that can go back into a river or lake via discharged cooling water. Low water levels could result in permit compliance issues due to reduced dilution and dispersion of heat and subsequent impacts on aquatic biota near outfalls.[18] However, the primary concern would be a loss of head (i.e., pressure) over intake structures that would decrease flows through intake tunnels. This would affect safety related pumps, increase operating costs and/or result in sustained shut-downs. Assuming plants did shutdown, they would not be able to generate electricity.

Among all water use categories, steam-electric is unique and cautions are needed when applying methods used in this study. Measured changes to an economy using input-output models stem directly from changes in sales revenues. In the case of water shortages, one assumes businesses will suffer lost output if process water is in short supply. For power generation facilities this is true as well. The electric services sector represents a corporate entity that may own and operate several electrical generating units in a given region. If one unit became inoperable due to water shortages, plants in other areas or generation facilities which do not rely heavily on water such as gas-powered turbines may be able to compensate for lost generating capacity. Utilities could also offset lost production via purchases on the spot market.[19] Thus, depending on the severity of the shortages and conditions at a given electrical

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18 Section 316 (b) of the Clean Water Act requires that thermal wastewater discharges do not harm fish and other wildlife.

19 Today, most utilities participate in large interstate “power pools” and can buy or sell electricity “on the grid” from other utilities or power marketers. Thus, assuming power was available to buy, and assuming that no contractual or physical limitations were in place such as transmission constraints; utilities could offset lost power that resulted from waters shortages with purchases via the power grid.

generating unit, energy supplies for local and regional communities could be maintained. But in general, without enough cooling water, utilities would have to throttle back plant operations, forcing them to buy or generate more costly power to meet customer demands.

### 4.7.10.10 Social Impacts from Water Shortages

The effects from water shortages can be social or economic. Distinctions between the two are semantic and analytical in nature—more so analytic in the sense that social impacts are harder to quantify. Social effects associated with drought and water shortages are closely tied to economic impacts. For example, they might include:

- Demographic effects such as changes in population,
- Disruptions in institutional settings including activity in schools and government,
- Conflicts between water users such as farmers and urban consumers,
- Health-related low-flow problems (e.g., cross-connection contamination, diminished sewage flows, increased pollutant concentrations),
- Mental and physical stress (e.g., anxiety, depression, domestic violence),
- Public safety issues from forest and range fires and reduced firefighting capability,
- Increased disease caused by wildlife concentrations,
- Loss of aesthetic and property values, and
- Reduced recreational opportunities.[20]

Social impacts measured focus strictly on demographic effects including changes in population and school enrollment. The social impact uses results from the economic component and assesses how changes in labor demand would affect migration patterns in a region. Declines in labor demand as measured are assumed to affect net economic migration in a given regional water planning area. Employment losses are adjusted to reflect the notion some people would not relocate but would seek employment in the region and/or public assistance and wait for conditions to improve. Changes in school enrollment are simply the proportion of lost population between the ages of 5 and 17. Estimated social impacts focus on changes in population and school enrollment. In 2010, estimated population losses total 24,433 with corresponding reductions in school enrollment of 6,891 students. In 2060, population in the region would decline by 175,389 people and school enrollment by 32,533 students.

### 4.7.10.11 Agricultural Water Shortages Impacts

According to the 2011 Region H Regional Water Plan, during severe drought the counties of Brazoria, Chambers, Galveston, Liberty, and Waller would experience irrigation water shortages without new management strategies. In 2010, shortages ranged from about 15 to 90 percent of annual irrigation demands. Shortages of these magnitudes would reduce gross state product (income plus state and local business taxes) by an estimated $68 million in 2010 and $61 million in 2060 with potential job losses ranging from 849 to 730.

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20 Based on information from the website of the National Drought Mitigation Center at the University of Nebraska Lincoln. Available online at: http://www.drought.unl.edu/risk/impacts.htm. See also, Vanclay, F. "*Social Impact Assessment*." in Petts, J. (ed) International Handbook of Environmental Impact Assessment. 1999.

#### 4.7.10.12 Municipal Water Shortages Impacts

Water shortages are projected to occur in a significant number of communities in Region H. At the regional level, the estimated economic value for domestic water shortages totals $97 million in 2010 and $4,798 million in 2060. Municipal shortages would also restrict operation for many commercial businesses reducing gross state product by an estimated $30 million in 2010 and $2,738 million in 2060.

#### 4.7.10.13 Manufacturing Water Shortages Impacts

Manufacturing water shortages in the region are projected to occur in Brazoria, Chambers, Fort Bend, Harris, Leon, Liberty, Madison, Montgomery, San Jacinto, Walker and Waller. The Region H planning group estimates these manufacturers would be short nearly 75,000 acre-feet of water in 2010 and 253,000 acre-feet in 2060. Shortages of these magnitudes would reduce gross state product (income plus taxes) by an estimated $2,939 million in 201 and $12,199 million in 2060.

#### 4.7.10.14 Mining Water Shortages Impacts

Mining water shortages in the region are projected to occur in Harris, Liberty, Montgomery and Polk counties, and would primarily affect the oil and gas and aggregates operations. In total, shortages would reduce gross state product by $35 million in 2010 and $233 million in 2060

#### 4.7.10.15 Steam-Electric Water Shortages Impacts

Water shortages for steam-electric water user groups are projected to occur in Fort Bend, Galveston, Harris, Liberty, and Montgomery counties, and would reduce gross state product by $380 million in 2010 and $5,238 million in 2060.

## 4.8 Hazardous Waste and Materials

The area of direct influence for Alternative 3A for hazardous waste and materials includes the proposed location for the Alternative 3A, 4 and 6 ROW including roads, pipeline, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines.

### 4.8.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur and there would be no impact to hazardous waste and materials in the vicinity of the proposed action alternatives.

### 4.8.2 Alternative 3A

Environmental Site Assessments (ESAs) were performed at properties identified for purchase or acquisition along the Alternative 3A ROW. No contaminants were discovered during these investigations. The soils in the vicinity of Alternative 3A were not expected to be contaminated. Excavated material would be used during construction of berms and maintenance roads. The proposed Alternative 3A canal would be a clay-lined structure. Clean clay material, if needed for the construction of the canal, would be imported during construction. Sanitary sewage may be generated during construction by workers. Portable toilets would be installed for use and periodically maintained with waste hauled off-site for treatment. A septic tank would be constructed at the proposed Capers Ridge Pump Station and at the SH 321 Alternative 3A maintenance facility to handle, treat, and dispose of sanitary wastewater. The septic tank and associated drain-field would be constructed according to Liberty County regulations.

No structures are located in the proposed Alternative 3A ROW with the exception of a communications tower that would be relocated to another pad site outside the proposed ROW. Culverts or similar concrete or chemically inert structures that may be used during construction may be reused or disposed of in a registered solid waste landfill (**Figure 2-33**).

It is unlikely that major, long term, widespread or permanent direct impacts due to hazardous waste or materials would occur as a result of construction, operation, or maintenance associated with Alternative 3A. Potential spills or releases could occur, however, from the operations area and the CRPS access or haul road. During operations, released materials could migrate toward wetlands or aquatic resource areas including riparian habitat. Releases could include fuel, lubricants, or other materials transported over the road. Depending on the nature and volume of released materials and the spill location, water quality impacts would range from negligible to substantial. An SPCC Plan would need to be prepared for the proposed LBITP. The plan would set forth the materials and practices, communication and response protocols, and training background to prevent and respond to potential spill events. Because there is the potential for water quality impacts to the lower Trinity River, San Jacinto River watershed, Lake Houston, Cedar Bayou and Luce Bayou and/or waterbodies on area floodplains associated with a hazardous materials spill, additional mitigation may be considered.

Runoff from the CRPS or TRPS haul road during its operational life would transport sediment and traffic residues to the lower Trinity River, Cedar Bayou or other area waterbodies within floodplains. During large storm events, the roadway drainage and sediment yield would contribute to water quality impacts. Individual occurrences of these impacts would be local, short-term, and minor to moderate in intensity. If road drainage and sediment were to periodically reduce water quality over the operating life of the road, repeated effects may create impacts of greater extent and severity.

### 4.8.3 Alternative 4 and Alternative 6

A TCEQ records review of Superfund Sites, Superfund Site Boundaries, and Permitted Industrial and Hazardous Waste Sites was conducted for Alternative 4 and Alternative 6.

Hazardous waste and materials identified are located at a distance of greater than 1,000 feet from Alternative 4 and Alternative 6 ROW; therefore there would be no impact during the construction, or operation and maintenance of these alternatives. Major, long term, widespread or permanent direct impacts due to hazardous waste or materials would not occur (**Figure 2-33**).

It is unlikely that major, long term, widespread or permanent direct impacts due to hazardous waste or materials would occur as a result of construction, operation, or maintenance associated with Alternative 3A. Potential spills or releases could occur, however, from the operations area and the CRPS access or haul road. During operations, released materials could migrate toward wetlands or aquatic resource areas including riparian habitat. Releases could include fuel, lubricants, or other materials transported over the road. Depending on the nature and volume of released materials and the spill location, water quality impacts would range from negligible to substantial.

Runoff from the TRPS access or haul road during its operational life would transport sediment and traffic residues to the lower Trinity River, Cedar Bayou or other area waterbodies within floodplains. During large storm events, the roadway drainage and sediment yield would contribute to water quality impacts. Individual occurrences of these impacts would be local, short-term, and minor to moderate in intensity. If road drainage and sediment were to periodically reduce water quality over the operating life of the road, repeated effects may create impacts of greater extent and severity.

#### 4.8.3.1 Reduction of Potential Impacts

During construction, and operation and maintenance phase of the proposed Alternative 3A, Alternative 4 or Alternative 6, an Spill Prevention, Control, and Countermeasure Plan (SPCC Plan) would need to be prepared and implemented for the proposed LBITP. The SPCC Plan would set forth the materials and practices, communication and response protocols, and training background to prevent and respond to potential spill events. In addition, construction contractors may take steps to protect human health and the environment in the event that contaminated soils or sediments are encountered during construction of the LBITP. All construction contractors, staff, and operators assigned to the operation and maintenance activities for LBITP would comply with SPCC plan requirements and specifications. Because there is the potential for water quality impacts to the lower Trinity River, San Jacinto River watershed, Lake Houston, Cedar Bayou and Luce Bayou and/or waterbodies on area floodplains associated with a hazardous materials spill, additional mitigation may be considered for implementation.

## 4.9 Social and Economic Resources

The area directly influenced by social and economic resources for the LBITP includes the proposed 300-foot ROW for the proposed project elements including roads, the pipeline easement, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines. For socioeconomic resources, the area of indirect effect includes the Region H RWP boundary (see **Figure 4-1**). Direct soil and economic effects are not anticipated to be significant for any of the action alternatives; these effects, however, are associated primarily with not implementing any of the proposed alternatives for the LBITP (Alternatives 3A, 4 or 6) so that an adequate supply of surface water is available to Houston through the 2040 planning year. Potentially significant effects of the No Build, or No Action Alternative are provided below in a tabulated summary format.

### 4.9.1 Environmental Justice

The area directly influenced by the LBITP for environmental justice populations includes the proposed location for the Alternatives 3A, 4 and 6 ROW including roads, pipeline, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines.

### 4.9.2 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no disproportionately high and adverse human health or environmental effects, on minority and low-income populations would occur.

### 4.9.3 Alternative 3A

The Alternative 3A area has four Census blocks in Liberty County and two in Harris County with greater than 50 percent minority populations. Of these four Census blocks, the alignment of Alternative 3A would be constructed directly through one (Block 1038 with a 64 percent minority population). This block has a population of 25 minority individuals that would be directly impacted by the construction of this alternative. Minority population data, including all geographic areas by Census tract, is provided in **Table 3-28**. Many Census blocks had a zero population due to the project area's rural nature.

### 4.9.4 Alternative 4

The Alternative 4 area has three Census blocks in Liberty County with greater than 50 percent minority populations. Minority population data, including all geographic areas by Census tract, are provided in **Table 3-28**. Many Census blocks had a zero population due to the project area's rural nature. Of these three Census blocks, the alignment of Alternative 4 would be constructed directly through all three (Block 1050 with 69 percent minority, Block 2008 with 69 percent minority, and Block 3002 with 62 percent minority). These blocks have a total population of 4,033 minority individuals that would be directly impacted by the construction of this alternative. Minority population data, including all geographic areas by Census tract, is provided in **Table 3-28**. Many Census blocks had a zero population due to the project area's rural nature.

The Alternative 4 alignment traverses an area containing several residential subdivisions, and large parcels with rural residences and agricultural operations. These populated areas are surrounded by wetlands and undeveloped lands. The construction of Alternative 4 would therefore cause land use changes and impacts to residential communities and agricultural operations; if rerouted to avoid these areas, the pipeline construction would impact wetlands, floodplains and cause habitat fragmentation for wildlife in the area.

### 4.9.5 Alternative 6

The Alternative 6 area has three Census blocks in Liberty County with greater than 50 percent minority populations. Of these three Census blocks, the alignment of Alternative 6 would be constructed directly through all three (Block 3044 with 51 percent minority, Block 3051 with 62 percent minority, and Block 3079 with 100 percent minority). These blocks have a total population of 322 minority individuals that would be directly impacted by the construction of this alternative. Minority population data, including all geographic areas by Census tract, is provided in **Table 3-28**. Many Census blocks had a zero population due to the project area's rural nature.

The Alternative 6 alignment traverses an area containing several residential subdivisions, and large parcels with rural residences and agricultural operations. These populated areas are surrounded by wetlands and undeveloped lands. The construction of Alternative 6 would therefore cause land use changes and impacts to residential communities and agricultural operations; if rerouted to avoid these areas, the pipeline would impact wetlands, floodplains, and cause habitat fragmentation for wildlife in the area.

#### 4.9.5.1 Reduction and Mitigation of Potential Impacts

During the final design stage of the LBITP alternatives, alignments for all action alternatives will be routed to follow property lines with the goal to avoid potential relocations and displacements. However, both Alternative 4 and Alternative traverse areas that contain several residential subdivisions, and large parcels with rural residences and agricultural operations. These populated areas are surrounded by wetlands and undeveloped lands including floodplains. The construction of Alternatives 4 and 6 would therefore cause land use changes and impacts to residential communities and agricultural operations; if rerouted to avoid these areas. Alternatives 4 and 6 would therefore impact wetlands, floodplains, vegetation important to wetlands functioning, and cause habitat fragmentation for wildlife in the area.

### 4.9.6 Economic Characteristics

Region H was able to address every projected water need through a combination of conservation, allocation of existing supply and development of new water supplies. However, the regional planning guidelines in 31 TAC §357 require that the social and economic impacts of not meeting demands be estimated and considered. The Water Use and Projection Section of the TWDB have performed social and economic impacts modeling for Region H. A description of the impact, model assumptions, and tabulated model results are presented as **Appendix 4E** in the Region H Regional Water Plan (**Appendix A**).

From a societal perspective, water supply sources and reliability are critical to public health and welfare. Water shortages combined with infrastructure limitations would likely curtail or eliminate economic activity in business and industries heavily reliant on water. Without water, farmers cannot irrigate; refineries cannot produce gasoline and paper mills cannot make paper and the public would not have adequate supplies of drinking water. Unreliable or limited water supplies would not only have an immediate and real impact on business and industry, but they might also bias corporate decision makers against plant expansion or plant location in Texas. Shortages would disrupt activity in homes, schools and government and could adversely affect public health and safety. For all of the above reasons, it is important to analyze and understand how restricted water supplies could affect communities throughout Texas.

## 4.9.7 Construction

The project would predominantly traverse undeveloped land. Alternative 3A would discharge into Lake Houston near the confluence with Luce Bayou. Construction, operation, and maintenance of Alternative 3A would permanently and directly impact more than 1,050 acres of property.

## 4.9.8 No Action

In 2005, the TWDB prepared a report summarizing the economic impact of unmet water needs by county for a number of economic indicators for the Region H Water Planning Area. Major economic indicators include lost output (sales), lost income, lost business taxes, and lost jobs. Socioeconomic impacts are divided by sector for each indicator not directly related to water service. Based on the analysis conducted in 2007, the proposed Alternative 3A is estimated to provide over $9 billion in sales and over 75,000 jobs to Region H from 2020 through 2060 (Region H RWP 2010; **Appendix A**).

Potentially significant effects of the No Action Alternative are provided below in a tabulated summary format.

**Table 4-27:**
**Harris and Liberty Counties Economic Impact of No Action**

| | | 2010 | 2020 | 2030 | 2040 | 2050 | 2060 |
|---|---|---|---|---|---|---|---|
| **Needs Met by Luce Bayou** | **Needs (MGD)** | 63.4 | 184.0 | 275.3 | 342.1 | 417.9 | 495.1 |
| | **Water Supplied by Luce Bayou (MGD)** | 0.0 | 42.7 | 94.1 | 167.5 | 237.4 | 349.0 |
| | **Percent of Needs met by Luce Bayou** | 0.00 | 23.21 | 34.18 | 48.95 | 56.82 | 70.49 |
| **Indicator** | **Lost Output** (millions) | $- | $ 998.16 | $ 2,471.92 | $ 4,332.96 | $ 5,828.58 | $ 9,294.82 |
| | **Lost Income** (millions) | $- | $ 460.44 | $ 1,212.00 | $ 2,135.14 | $ 2,958.46 | $ 5,308.55 |
| | **Lost Business Taxes** (millions) | $- | $ 36.13 | $ 105.56 | $ 191.69 | $ 275.04 | $ 612.40 |
| | **Lost Jobs** | 0 | 6,977 | 19,523 | 34,210 | 47,472 | 75,516 |
| | **Lost Water Utility Revenues** (millions) | $- | $ 37.72 | $ 86.65 | $ 150.11 | $ 205.93 | $ 298.18 |
| | **Costs to Non-Water Intensive Commercial Businesses and Households** (millions) | $- | $ 120.06 | $ 322.50 | $ 607.49 | $ 943.40 | $ 1,404.36 |

## 4.9.9 Alternative 3A, Alternative 4, Alternative 6

The area directly influenced by Alternatives 3A, 4 and 6 for economic characteristics includes the proposed project ROW areas including roads, pipeline, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines.

A variety of tools are available to estimate such impacts, but by far, the most widely used today are input-output models (IO models) combined with social accounting matrices (SAMs). Referred to as IO/SAM models, these tools formed the basis for estimating economic impacts for agriculture (irrigation and livestock water uses) and industry (manufacturing, mining, steam-electric and commercial business activity for municipal water uses).

Basically, an IO/SAM model is an accounting framework that traces spending and consumption between different economic sectors including businesses, households, government and "foreign" economies in the form of exports and imports. There is a highly aggregated segment of the IO/SAM model that focuses on key agricultural sectors in a local economy. Local economies and the agricultural sectors include cattle ranchers, dairies and alfalfa farms.

Sales from each sector to other local industries and institutions including households, government and consumers outside of the region are considered in the model as a form of export or output. Purchases (inputs) by each sector are provided for the economic analyses in a similar fashion. The dairy industry may purchase $11.62 million worth of goods and services needed to produce milk and local alfalfa farmers provide $2.11 million worth of hay while local households provide about $1.03 million worth of labor. Dairies import $4.17 million worth of inputs and pay $2.61 million in taxes and profits. The total economic activity in the region amounts to about $807.45 million. The analyses conducted by Region H provides these input and output calculations similar to an accounting balance sheet where total sales equal total purchases.

The methodology used to estimate regional economic impacts consists of three steps:

- Develop IO/SAM models for each county in the region and for the region as whole
- Estimate direct impacts to economic sectors resulting from water shortages
- Calculate total economic impacts (i.e., direct plus secondary effects)

The following variables are used with the IO/SAM models and have the following meaning when used to evaluate the regional economic effects of the anticipated action or activities.

- Total sales - total production measured by sales revenues
- Intermediate sales - sales to other businesses and industry within a given region
- Final sales – sales to end users in a region and exports out of a region
- Employment - number of full and part-time jobs (annual average) required by a given industry including self-employment
- Regional income - total payroll costs (wages and salaries plus benefits) paid by industries, corporate income, rental income and interest payments
- Business taxes - sales, excise, fees, licenses and other taxes paid during normal operation of an industry (does not include income taxes)

TWDB analysts developed an economic baseline containing each of the above variables using year 2000 data. Since the planning horizon extends through 2060, economic variables in the baseline were allowed to change in accordance with projected changes in demographic and economic activity. Growth rates for municipal water use sectors (i.e., commercial, residential and institutional) are based on TWDB population forecasts. Projections for manufacturing, agriculture, and mining and steam-electric activity are based on the same underlying economic forecasts used to estimate future water use for each category. Monetary impacts in future years are reported in year 2000 dollars.

As mentioned above, direct impacts accrue to immediate businesses and industries that rely on water. Without water, industrial processes could suffer. However, output responses would likely vary depending upon the severity of a shortage. A small shortage relative to total water use may have a nominal effect, but as shortages became more critical, effects on productive capacity would increase.

To account for uncertainty regarding the relative magnitude of impacts to farm and business operations, the following analysis employs the concept of elasticity. Elasticity is a number that shows how a change in one variable will affect another. An elasticity of 0.50 would indicate that for every 1.0 percent of unavailable water, output is reduced by 0.50 percent and so on. Output elasticities and assumptions used in this study are:21

- When unmet water needs are 0 to 5 percent of total water demand, no corresponding reduction in output is assumed
- When water shortages are 5 to 30 percent of total water demand, for every 1.0 percent of unmet need, there is a corresponding 0.25 percent reduction in output
- When water shortages are 30 to 50 percent of total water demand, for every 1.0 percent of unmet need, there is a corresponding 0.50 percent reduction in output
- When water shortages are greater than 50 percent of total water demand, for every 1.0 percent of unmet need, there is a corresponding 1.0 percent (i.e., a proportional reduction)

Once output responses to water shortages were estimated, direct impacts to total sales, employment, regional income, and business taxes were derived using regional level economic multipliers using IO/SAM models. When calculating direct effects for the municipal, steam electric, manufacturing and livestock water use categories, sales to final demand were applied to avoid double counting impacts.

IO/SAM models are not well suited for measuring impacts of shortages for domestic uses, which make up the majority of the municipal category.[22] To estimate impacts associated with domestic uses, municipal water demand and thus needs were subdivided into two categories – residential and commercial. Residential water is considered "domestic" and includes water that people use in their homes for things such as cooking, bathing, drinking and removing household waste and for outdoor purposes including lawn watering, car-washing and swimming pools. Shortages to residential uses were valued using a tiered approach. In other words, the more severe the shortage, the more costly it becomes. For instance, a 2 acre-foot shortage for a group of households that use 10 acre-feet per year would not be as severe as a shortage that amounted to 8 acre-feet. In the case of a 2 acre-foot shortage, households would probably have to eliminate some or all outdoor water use, which could have implicit and explicit economic costs including losses to the horticultural and landscaping industry.

In the case of an 8 acre-foot shortage, people would have to forgo all outdoor water use and most indoor water consumption. Economic costs would be much higher in this case because people could probably not live with such a reduction, and would be forced to find emergency alternatives. The alternative assumed in this study is a very uneconomical and worst-case scenario (i.e., hauling water in from other communities by truck or rail).

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21 Elasticities are based on one of the few empirical studies that analyze potential relationships between economic output and water shortages in the United States. The study, conducted in California, showed that a significant number of industries would suffer reduced output during water shortages. Using a survey based approach researchers posed two scenarios to different industries. In the first scenario, they asked how a 15 percent cutback in water supply lasting one year would affect operations. In the second scenario, they asked how a 30 percent reduction lasting one year would affect plant operations. In the case of a 15 percent shortage, reported output elasticities ranged from 0.00 to 0.76 with an average value of 0.25. For a 30 percent shortage, elasticities ranged from 0.00 to 1.39 with average of 0.47. For further information, see, California Urban Water Agencies, "*Cost of Industrial Water Shortages*." Prepared by Spectrum Economics, Inc. November, 1991.

22 A notable exception is the potential impacts to the nursery and landscaping industry that could arise due to reductions in outdoor residential uses and impacts to "water intensive" commercial businesses.

The effects of water shortages can be social, economic or both. Distinctions between the two are both semantic and analytical in nature – more so analytic in the sense that social impacts are much harder to measure in quantitative terms. Nevertheless, social effects associated with water shortages usually have close ties to economic impacts. For example, they might include:

- Demographic effects such as changes in population
- Disruptions in institutional settings including activity in schools and government
- Conflicts between water users such as farmers and urban consumers
- Health-related low-flow problems (e.g., cross-connection contamination, diminished sewage flows, increased pollutant concentrations)
- Mental and physical stress (e.g., anxiety, depression, domestic violence)
- Public safety issues from forest and range fires and reduced fire fighting capability
- Increased disease caused by wildlife concentrations
- Loss of aesthetic and property value
- Reduced recreational opportunities.[23]

Social impacts measured in this study focus strictly on demographic effects including changes in population and school enrollment. Methods are based on models used by the TWDB for state water planning and by the U.S. Census Bureau for national level population projections. With the assistance of the Texas State Data Center (TSDC), TWDB staff modified population projection models used for state water planning and applied them here. Basically, the social impact model incorporates results from the economic component of the study and assesses how changes in labor demand due to unmet water needs could affect migration patterns in a region. Before discussing particulars of the approach model, some background information regarding population projection models is useful in understanding the overall approach.

Other considerations include the “welfare” losses to consumers who had to forgo outdoor and indoor water uses to reduce needs. In other words, the water that people would have to give up has an economic value. Estimating the economic value of this forgone water for each planning area would be a very time consuming and costly task, and thus secondary sources served as a proxy. Previous research funded by the TWDB, explored consumer “willingness to pay” for avoiding restrictions on water use.[24] Surveys revealed that residential water consumers in Texas would be willing to pay – on average across all income levels - $36 to avoid a 30 percent reduction in water availability lasting for at least 28 days.

Assuming the average person in Texas uses 140 gallons per day and the typical household in the state has 2.7 persons (based on U.S. Census data), total monthly water use is 13,205 gallons per household. Therefore, the value of restoring 30 percent of average monthly water use during shortages to residential consumers is roughly one cent per gallon or $2,930 per acre-foot. This figure serves as a proxy to measure consumer welfare losses that would result from restricted outdoor uses and emergency indoor restrictions.

The above data help address the impacts of incurring water needs that are 50 percent or less of projected use. An amount greater than 50 percent would result in municipal water consumers having to seek alternative sources. Costs to residential and non-water intensive commercial operations (i.e., those that use water only for sanitary purposes) are based on the most likely alternative source of water in the absence of water management strategies.

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23 Based on information from the website of the National Drought Mitigation Center at the University of Nebraska Lincoln. Available online at: http://www.drought.unl.edu/risk/impacts.htm. See also, Vanclay, F. “*Social Impact Assessment*.” in Petts, J. (ed) International Handbook of Environmental Impact Assessment. 1999.

24 See, Griffin, R.C., and Mjelde, W.M. “*Valuing and Managing Water Supply Reliability*. Final Research Report for the Texas Water Development Board: Contract no. 95-483-140.” December 1997.

In this case, the most likely alternative is assumed to be “hauled-in” water from other communities at annual cost of $6,530 per acre-foot for small rural communities and approximately $10,995 per acre-foot for metropolitan areas.[25]

This is not an unreasonable assumption. It happened during the 1950s drought and more recently in Texas and elsewhere. For example, in 2000 at the heels of three consecutive drought years Electra - a small town in North Texas - was down to its last 45 days worth of reservoir water when rain replenished the lake, and the city was able to refurbish old wells to provide supplemental groundwater. At the time, residents were forced to limit water use to 1,000 gallons per person per month - less than half of what most people use - and many were having hauled water delivered to their homes by private contractors.[26] In 2003 citizens of Ballinger, Texas, were also faced with a dwindling water supply due to prolonged drought. After three years of drought, Lake Ballinger, which supplies water to more than 4,300 residents in Ballinger and to 600 residents in nearby Rowena, was almost dry. Each day, people lined up to get water from a well in nearby City Park.

Trucks hauling trailers outfitted with large plastic and metal tanks hauled water to and from City Park to Ballinger.[27] In Australia, four cities have run out of water as a result of drought, and residents have been trucking in water since November 2002. One town has five trucks carting about one acre-foot eight times daily from a source 20 miles away. They had to build new roads and infrastructure to accommodate the trucks. Residents are currently restricted to indoor water use only.[28]

Estimated social impacts focus changes including population loss and subsequent reduction in school enrollment. As shown in **Table 4-23**, water shortages in 2010 could result in a population loss of 42,750 people with a corresponding reduction in school enrollment of 10,500. Models indicate that shortages in 2060 could cause population in the region to fall by 269,610 people and school enrollment by 66,230 students.

**Table 4-23:**
**Estimated Regional Social Impacts of Unmet Water Needs by Decade**

| Year | Population Losses | Declines in School Enrollment |
|---|---|---|
| 2010 | 42,750 | 10,500 |
| 2020 | 82,070 | 20,160 |
| 2030 | 144,925 | 35,600 |
| 2040 | 185,365 | 45,535 |
| 2050 | 221,955 | 54,520 |
| 2060 | 269,610 | 66,230 |

Source: Generated by the Texas Water Development Board, Office of Water Resources Planning (2011).

25 For rural communities, figure assumes an average truck hauling distance of 50 miles at a cost of 8.4 cents per ton-mile (an acre foot of water weighs about 1,350 tons) with no rail shipment. For communities in metropolitan areas, figure assumes a 50 mile truck haul, and a rail haul of 300 miles at a cost of 1.2 cents per ton-mile. Cents per ton-mile are based on figures in: Forkenbrock, D.J., “*Comparison of External Costs of Rail and Truck Freight Transportation*.” Transportation Research. Vol. 35 (2001).

26 Zewe, C. “*Tap Threatens to Run Dry in Texas Town*.” July 11, 2000. CNN Cable News Network.

27 Associated Press, “*Ballinger Scrambles to Finish Pipeline before Lake Dries Up*.” May 19, 2003.

28 Healey, N. (2003) *Water on Wheels*, Water: Journal of the Australian Water Association, June 2003.

Analyses developed illustrate economic impacts by county and water user group; however, **caution** is warranted. These data compiled for specific counties summarize *direct* impacts only. For the most part, data reported for all water use categories uses include *direct and secondary* impacts. Secondary effects were estimated using regional level multipliers that treat each regional water planning area as an aggregate and autonomous economy. Multipliers do not specify where secondary impacts will occur at a sub-regional level (i.e., in which counties or cities). All economic impacts that would accrue to a region as a whole due to secondary economic effects are reported by the TWDB in their reports as “secondary regional level impacts.”

For example, assume that in a given county (or city) water shortages caused significant reductions in output for a manufacturing plant. Reduced output resulted in lay-offs and lost income for workers and owners of the plant. This is a *direct* impact. Direct impacts were estimated at a county level; and thus one can say with certainty that direct impacts occurred in that county. However, secondary impacts accrue to businesses and households throughout the region where the business operates, and it is impossible using input-output models to determine where these businesses are located spatially.

The same logic applies to changes in population and school enrollment. Since employment losses and subsequent out-migration from a region were estimated by the TWDB using *direct* and *secondary* multipliers, it is not possible to know how many people within a given county would experience an economic loss regardless of whether the economic impact was direct or secondary. For example, assume the manufacturing plant referred to above is in County A. If the firm eliminated 50 jobs, one could state with certainty that water shortages in County A resulted in a loss of 50 jobs in that county. However, one could not unequivocally say whether 100 percent of the population loss due to lay-offs at the manufacturing would accrue to County A because many affected workers may commute from adjacent counties. This is particularly true in large metropolitan areas that overlay one or counties. Therefore, population and school enrollment impacts cannot be accurately reported at a county level.

### 4.9.10 Reduction and Mitigation of Potential Impacts

Construction of the proposed LBITP would have direct, indirect, and induced effects on local, regional, and state employment, output, and income. Direct effects include those arising from purchases made related to construction activities, such as gasoline, fuel, housing, food, supplies, rental or leased equipment, and other goods and services. Direct costs include wages and salaries paid to workers directly engaged in the project’s construction, as well as capital costs for equipment, materials, and supplies during construction. In the short term, implementation of the project would have a beneficial effect on the area’s economy through the creation of construction jobs (direct jobs greater than 3,000) and an increase in personal income (more than $63 million) related to the construction period. There would be permanent jobs created by the CWA for maintenance activities and pump station operators. The number of permanent jobs created would likely be less than 20. During construction, area businesses, such as gas stations, convenience stores, and restaurants, would likely experience an increase in revenue due to the increase in construction workers in the communities. The property acquired for the project would be removed from the tax role, creating a limited decrease in property tax revenue for Harris and Liberty Counties, Texas. The costs for implementing the project would be shared by customers through user fees.

Alternative 3A would not impact community or public resources. The proposed mitigation area is planned to be deeded to the USFWS and included with the TRNWR. This action would provide an additional public resource for Liberty County. Other than the addition of the mitigation area to the TRNWR, there would be no other benefit to local community and public resources as a result of the implementation of Alternative 3A.

### 4.9.11 Navigation and Safety

The area directly influenced by the action alternatives for navigation, recreation, and safety includes the areas of lower Trinity River and Luce Bayou/Lake Houston where LBITP structures would be located. No commercial navigation occurs within any of the LBITP watersheds; navigational effects are related to recreation.

### 4.9.12 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, impacts to navigation and safety would not occur.

### 4.9.13 Alternative 3A, Alternative 4, and Alternative 6

The lower Trinity River segment in the vicinity of the LBITP is not used for commercial navigation and, therefore, no impacts to regional commercial shipping would occur. See **Section 4.7** relative to potential impacts to recreational boating and canoeing. Navigation occurring in the Trinity River and Lake Houston would not be adversely affected by the construction, operation, and maintenance of the action alternatives, although construction activities may result in short-term restrictions to recreational boat traffic in the immediate construction area. Navigational safety in the Trinity River during construction and operation of the CRPS would occur through adherence and requirements of the U.S. Coast Guard. These navigational safety measures and procedures would be developed through coordination with the U.S. Coast Guard during the final design phase. Navigational signs would be placed along or in the Trinity River according to U.S. Coast Guard standards to warn boaters of the CRPS construction and to create a construction buffer zone.

Security measures along the canal and LBITP Alternative 3A ROW are under evaluation. At present, the preliminary LBITP design incorporates the use of a 4-strand barb wire fence along the entire LBITP ROW alignment except at major roadway and pipeline or utility easement crossings. In these locations, a 6-foot chain-link fence may be used to deter trespass and address safety and security concerns in areas with available public access such as at roadway crossings.

With the heightened terrorist threat in the United States, it is important to manage security concerns associated with the LBITP water transfer to Lake Houston, a Houston metropolitan area drinking water supply source. Contamination through biological agents would be a concern in open water situations such as canals or channels. At roadway and other crossings, the raw water from the Trinity River could be contaminated and source water protection would be addressed to control threats to public safety related to source water protection requirements as implemented by the EPA.

In terms of citizen safety, installation of fencing surrounding the LBITP canal would be necessary to prevent accidental, water-related injuries from occurring. In areas of frequent public access, such as at the proposed mitigation property that would become part of the Trinity River National Wildlife Refuge (TRNWR), alternative security concerns would be addressed. Facilities constructed or installed as part of the LBITP within the boundaries of the proposed mitigation property that would become public property would include the below-grade pipelines, above-grade pipeline valve boxes and other pipeline access points, CRPS and pipeline maintenance access roads, sedimentation basin and sediment storage area, and the start of the canal section adjoining the sediment basin within the proposed 300-foot LBITP ROW. The proposed LBITP facilities encompassed within the boundaries of the would be owned by the Coastal Water Authority, would be enclosed with security fencing, and would be locked with warning signs, and access would be denied to the public and USFWS staff. There will be designated crossings to provide access to the proposed mitigation site for the public and USFWS staff after property transfer to the TRNWR. No boat ramps or other river access to the proposed TRNWR would be constructed as part of the LBITP. The CRPS facilities at the Trinity River would be surrounded by security chain-link fencing topped with 4-strand barb wire and would contain ownership information and no trespassing signage.

### 4.9.14 Reduction and Mitigation of Potential Impacts

The physical security of the proposed CRPS (Alternative 3A and Alternative 4) and the existing TRPS (Alternative 6) would incorporate EPA requirements in accordance with the 2010 National Infrastructure Protection Plan.

**Background**: One of the outcomes of the Department of Homeland Security's Presidential Directives (HSPDs) and the Public Health Security and Bioterrorism Preparedness and Response Act (Bioterrorism Act) of 2002 specifically denote the responsibilities of EPA and the water sector in:

- Assessing vulnerabilities of water utilities
- Developing strategies for responding to and preparing for emergencies and incidents
- Promoting information exchange among stakeholders
- Developing and using technological advances in water security

These directives and laws supplement existing legislation, such as the Safe Drinking Water Act and the Clean Water Act, which have always had the goals of promoting a clean and safe supply of water for the nation's population and protecting the integrity of the nation's waterways. These directives and laws affect the actions and obligations of EPA, the Water Security Division, and water utilities. The following directives are relevant to water security issues:

- HSPD 7: Critical Infrastructure Identification, Prioritization, and Protection
- HSPD 8: National Preparedness
- HSPD 9: Defense of United States Agriculture and Food
- HSPD 10: Biodefense for the 21st Century

*Guidelines for Physical Security of Water Utilities* was developed for the EPA by the American Society of Civil Engineers and the American Water Works Association. by the HSPD 7 designates EPA as the sector specific agency responsible for infrastructure protection activities for the nation's drinking water and wastewater systems. As such, EPA is responsible for:

- Identifying, prioritizing, and coordinating infrastructure protection activities for the nation's drinking water and water treatment systems
- Working with federal departments and agencies, state and local governments, and the private sector to facilitate vulnerability assessments
- Encouraging the development of risk management strategies to protect against and mitigate the effects of potential attacks on critical resources
- Developing mechanisms for information sharing and analysis

Under HSPD 7, the Water Security Division has been tasked with developing a water sector specific plan as input to the National Infrastructure Protection Plan that the Department of Homeland Security must produce. The sector specific plan must address processes for:

- Identifying assets within the sector
- Identifying and assessing vulnerabilities, and prioritizing assets within the sector
- Developing sector specific strategic protective programs
- Measuring the effectiveness of the sector specific critical infrastructure protection program

HSPD 8 establishes policies to strengthen the preparedness to prevent and respond to threatened or actual domestic terrorist attacks, major disasters, and other emergencies by establishing mechanisms for improved delivery of federal preparedness assistance to state and local governments.

Under HSPD 9, EPA is to develop a robust, comprehensive surveillance and monitoring program to provide early warning in the event of a terrorist attack using biological, chemical, or radiological contaminants.

HSPD 9 also directs EPA to develop a nationwide laboratory network to support the routine monitoring and response requirements of the surveillance program. HSPD 10, which is currently a classified document, basically reaffirms EPA's responsibilities under HSPD 9 while adding a clear directive on the Agency's responsibilities in decontamination efforts.

***Water Security Initiative***: EPA is implementing a demonstration project program to design, deploy, and evaluate a model contamination warning system for drinking water security. The program, which is being developed in partnership with select cities and laboratories, responds to a Homeland Security Presidential Directive that charges EPA to develop surveillance and monitoring systems to provide early detection of water contamination.

***Water Laboratory Alliance***: The purpose of the WLA is to provide the drinking water sector with an integrated nationwide network of laboratories with the analytical capabilities and capacity to support monitoring and surveillance, response, and remediation of intentional and unintentional drinking water supply contamination events involving chemical, biological, and radiochemical contaminants.

HSPD 10 provides directives to further strengthen the Biodefense Program through threat awareness, prevention and protection, surveillance and detection, and response and recovery.

The Water Sector-Specific Plan is a broad-based Water Sector critical infrastructure protection implementation strategy developed under the Department of Homeland Security's National Infrastructure Protection Plan and was produced by EPA in coordination with Water Sector security partners which includes our Water Sector Coordinating Council and Government Coordinating Council. The Water SSP is an annex to the 2010 National Infrastructure Protection Plan.

The developed portion of the LBITP, where the pump station, control building, electrical switchyard, electrical building, maintenance building, etc. are located, will have a constructed perimeter fence. The fence would be constructed along the river and bayou/lake shoreline to the pump station or discharge location on both sides to prevent access to these facilities. This perimeter fence will be constructed to resist climbing or cutting. The fence fabric will be heavy gauge chain link or welded wire fabric construction that would be least 6 feet tall with double outriggers on top with either three strands of barbed wire on both sets of outriggers or coiled razor wire. The entrance gate into this area will be an automated type sliding gate. Access through the gate will be controlled by the access control functions of the integrated security system at the site that will be discussed under the Electronic Security section. All manholes, valve, vault hatches, equipment control cabinets, control devices, etc will be secured with shrouded locks. All personnel doors into the facilities at this site will be equipped with tamper resistant security hinges and key-locked doors. Each main entrance into each building will also be equipped with an access control card reader and associated hardware. Any roof hatches or exterior roof access ladders would need to be locked.

**Electronic Security for the Proposed CRPS and Existing TRPS:** Electronic security for this facility consists of access control for the main gate, and each of the main buildings, specifically the control building, electrical building, and maintenance building and would include CCTV coverage of the entrances into each of these buildings, the main gate and the pump station. The CCTV coverage of the building entrances is from the inside of the buildings looking out in order to obtain a usable image for identifying who is entering the building. The camera at the entry gate will require lighting for use 24 hours per day and 7 days per week and the camera overlooking the propsed CRPS and existing TRPS would require lighting for continuous. Communications between these systems and the monitoring point at the Coastal Water Authority would also be required.

**Alternative Conveyance Facilities (Pipeline vs Open Earthen Canal):** The pipeline segments for Alternative 3A 4, and 6 would consist of two, 9-foot in diameter pipelines buried 6 feet below the surface with the base of the pipelines resting at approximately 15 feet below the land surface elevation. The pipeline easements would consist of graded, mounded, and maintained easements that would include access roads and fences (two, side-by-side 9-foot diameter pipes installed up to 15 feet deep) and would permanently change local topography along the pipeline route for Alternative 4 that would extend more than 15 miles across the north-central portion of Liberty County. Alternative 6 would extend more than 10 miles across central Liberty County. Although the ROWs would be re-contoured after construction, it is expected that the easement would be at least 23 miles (Alternative 4) or 21 miles (Alternative 6) long. The surface expression of the project would be linear, elevated, mounded, and bermed surface feature with side access roads, fencing, and drainage ditches. The Alternative 3A canal would also extend a distance of approximately 23 miles across northern Liberty County and would consist of an earthen, open channel canal with 4:1 side slopes and flow control structures. The average depth of water in the open canal is anticipated to be 7 feet. To maintain this water surface elevation, water level control gates would need to be installed along the LBITP canal at various points to be identified during final design. In general, these gates would operate under gravity and would allow more water through the structure when upstream flow levels increase and would restrict water passage when upstream flows levels drop below a certain elevation.

For all alternatives, the above ground valves or controls will need to be locked with shrouded locks. Site access points have been identified throughout the LBITP alignment and the majority of these site access points are located adjacent to areas where the LBITP ROW would be crossing an existing roadway.

In addition to the facilities surrounding a pump station, additional facilities would be needed at various locations along the pipeline or canal route. The number and extent of these facilities depends on the frequency of maintenance and the length of the pipeline. Weekly or daily visits would require the construction of a building for offices and an equipment storage building. A residential facility would be needed if constant oversight would be required. This would be determined during final design and the development of an Operations Plan and would be based on CWA requirements.

#### 4.9.14.1 Alternative 3A

There are two locations along the channel that require the addition of security enhancements. The first is the water control structure. The PLC cabinets, manual controls and valves need to be locked using shrouded locks. The second is the canal maintenance facility. This maintenance facility will be surrounded by a a perimeter fence. This perimeter fence will be constructed to resist climbing or cutting. The fence fabric will be heavy gauge chain link or welded wire fabric construction. It should be at least 6 ft tall with double outriggers on top with either three strands of barbed wire on both sets of outriggers or coiled razor wire. The entrance gate into this area will be an automated type sliding gate. The gate providing direct access to the canal will be secured with a shrouded lock. Access through the main gate will be controlled by the access control functions of the integrated security system at the site that will be discussed under the Electronic Security section. All manholes, valve, vault hatches, equipment control cabinets, control devices, etc will be secured with shrouded locks. All personnel doors into the facilities at this site will be equipped with tamper resistant security hinges and key-locked doors. Each main entrance into each building will also be equipped with an access control card reader and associated hardware. All roof hatches or exterior roof access ladders will be locked. Electronic security for this facility consists of access control for the main gate, and each of the main buildings, specifically the offices, vehicle maintenance bays, parts storage, general maintenance, and used oil storage. Security cameras would include CCTV coverage of the entrances into each of these buildings/facilities and the main gate. The CCTV coverage of the building entrances is from the inside of the buildings looking out in order to obtain a usable image for identifying who is entering the building. The camera at the entry gate will require lighting for use at all times. Communications between these systems and the monitoring point at the Coastal Water Authority would occur. All PLC cabinets, control valves, etc. associated this the canal need to be secured with shrouded locks.

For Alternative 3A, other than the proposed surrounding wildlife friendly, barb-wire fence, there would be no additional security enhancements that would be needed for the earthen open canal itself due to the remoteness of the location and lack of property access of the proposed canal.

#### 4.9.14.2 Alternative 4

Alternative 4 is approximately 23.9 miles and directly affects approximately 885 acres of land (excluding the proposed approximate 90 acre CRPS and the proposed 10 acre maintenance facility), it is anticipated that due to the nature and location of area development combined with the location of Alternative 4, a significant portion of the proposed pipeline alignment and easement would need security enhancements. The length of the proposed pipeline easement would increase the costs of fencing, CCTV cameras, and other security features. The anticipated costs for proposed pipeline security would be estimated at $5 million.

#### 4.9.14.3 Alternative 6

Alternative 6 is 21.4 miles long and directly affects approximately 725 acres of land (excluding the TRPS and the proposed 10 acre maintenance facility), it is anticipated that due to the nature and location of area development combined with the location of Alternative 6, a significant portion of the proposed alignment would need security enhancements. The length of the proposed pipeline easement would increase the costs of fencing, CCTV cameras, and other security features. The anticipated costs for proposed pipeline security would be estimated at $7 million.

### 4.9.15 Energy and Mineral Resources

The area directly influenced by Alternative 3A for energy and mineral resources includes the proposed location for the Alternative 3A ROW including roads, pipeline, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines.

#### 4.9.15.1 No Action

Under the No Action Alternative, the proposed project would not be constructed or operated. As a result, no construction activities would occur and there would be no impact to energy and mineral resources in the vicinity of the proposed action alternatives.

#### 4.9.15.2 Alternative 3A

ENSTOR HUB and Storage facility has permitted a natural gas pipeline (NGPL) Interconnect Meter Site near the central part of the proposed ROW and the proposed canal crosses through that area. In addition, there is one drilled well located within 500 feet of the proposed canal alignment. No electrical power corridors were identified within the ROW of the proposed Alternative 3A and no oil wells are located in the proposed Alternative 3A footprint, although there is a dry hole present in the vicinity of the sedimentation basin. No other energy or mineral resources were identified within the proposed project ROW.

No mitigation has been identified regarding the potential impacts from the proposed Alternative 3A ROW on potential gas field development and the planned Houston HUB Storage Project. Coordination with Gordy Oil Company and ENSTOR would be conducted to determine any possible mitigation measures needed prior to construction.

#### 4.9.15.3 Alternative 4

Approximately 19 electrical power corridors were identified as crossing the ROW of proposed Alternative 4.

#### 4.9.15.4 Alternative 6

Approximately 10 electrical power corridors were identified as crossing the ROW of proposed Alternative 6.

It is unlikely that major, long term, widespread or permanent direct impacts to energy and mineral resources would occur as a result of construction, operation, or maintenance of Alternatives 3A, 4 or 6.

#### 4.9.15.5 Reduction and Modification of Potential Impacts

Consultation with appropriate electrical and natural gas utility providers prior to construction will assure a coordinated effort and schedule.

At this time, no mitigation has been identified regarding the potential impacts from the proposed Alternative 6 ROW on potential gas field development. Coordination with the oil companies owning or operating the impacted oil and gas facilities would be conducted to determine any possible mitigation measures needed prior to construction.

### 4.9.16 Roads and Infrastructure

#### 4.9.16.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, impacts to roads and infrastructure would not occur.

#### 4.9.16.2 Alternative 3A, Alternative 4, and Alternative 6

No direct or permanent impacts to the road and infrastructure network are anticipated as a result of construction, operation, or maintenance associated with Alternative 3A, 4 or 6. The proposed canal would flow underground at roadway crossings. Fencing would be constructed to prevent vehicle and pedestrian access at roadway and other infrastructure crossings.

#### 4.9.16.3 Reduction and Mitigation of Potential Impacts

During construction, a Traffic Control Plan would need to be developed in order to minimize and control effects to traffic, roads and infrastructure.

### 4.9.17 Food and Fiber Production

The area directly influenced by the proposed action alternatives for food and fiber production includes the proposed location for the proposed ROW including roads, pipeline, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines.

#### 4.9.17.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, food and fiber production in the area would remain unchanged

#### 4.9.17.2 Alternative 3A, Alternative 4, and Alternative 6

No direct or permanent impacts to the road and infrastructure network are anticipated as a result of construction, operation, or maintenance associated with Alternative 3A, 4 or 6. The proposed canal would flow underground at roadway crossings. Fencing would be constructed to prevent vehicle and pedestrian access at roadway and other infrastructure crossings.

# 4.10 Public Health and Welfare

## 4.10.1 Noise

The direct influence area for noise and the sound environment includes the proposed location for any build alternative including roads, pipeline, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines.

Sound is a physical phenomenon consisting of minute vibrations that travel through a medium, such as air, and are sensed by the human ear. Noise is defined as an undesirable sound which interferes with communication, is intense enough to damage hearing, or is otherwise intrusive. Noise is characterized by many variables including frequency, duration and intensity. Sound pressure level (SPL), described in decibels (dB), is used to quantify sound intensity. The dB is a logarithmic unit which expresses the ratio of an SPL to a standard reference level. Hertz (Hz) are used to quantify sound frequency. Sound levels are expressed either as instantaneous values or averaged over standard durations such as 1-hour, 8-hour and 24-hour periods. Human hearing is less sensitive to low frequencies and extremely high frequencies, and most sensitive to mid-range frequencies.

The most widely accepted method used to quantify sound for human receptors is to measure sound across a wide frequency spectrum and apply a weighting known as “A-weighting” to the individual dB value for each frequency interval. The logarithmic sum of these values is known as the A-weighted sound level, expressed as dB A-weighted units, or dBA (i.e., equivalent constant dBA sound level (Leq) of the same duration). Normal speech is typically about 60 dB sound level.

The ability to perceive changes in noise levels varies widely from person to person, as do individuals’ responses to perceived changes. In general, a 3-dBA change in noise level is barely perceptible to most listeners. A 10-dBA change is normally perceived as doubling (or halving) noise levels, and is considered a substantial change. Noise thresholds make it possible to estimate a person’s probable perception of changes in noise levels.

Human response to noise varies depending on the noise type and characteristics, distance between the noise source and the receptor, receptor sensitivity, and time of day. Noise can interfere with communication; awaken people from sleep; damage the eardrum; or affect wildlife. Noise is often generated by activities essential to a community’s quality of life such as construction or vehicular traffic.

## 4.10.2 Noise Study

A noise study was conducted in 2009 to measure noise at the existing Trinity River pump station. The study was conducted to study noise effects on nearby wildlife, but results also addressed noise effects on the human environment. Noise contours were estimated from integrated noise levels (Leq) at three locations in 15-minute intervals. To estimate the worst case noise scenario, the existing Trinity River pump station was run at full capacity with four pumps running at once. Contours were drawn between pairs of points spanning the contour interval, using the topography shown on the engineering plans sheets provided by the CWA. Since the layout of the TRPS is very similar to the proposed CRPS, the contour lines were superimposed on to the proposed layout of the CRPS to estimate expected noise. The contours shown at the CRPS were rotated to match the proposed location of the pumps (**Figure 4-13**).

Due to the location of both pump stations, impacts to residential communities or environmental justice populations were not analyzed in detail. For both locations, residential homes were outside the 50dB range and would sound no louder than existing background noise levels. As discussed in **Chapter 2**, Alternatives 3A and 4 (**Figure 4-13**) would use the proposed CRPS and Alternative 6 (**Figure 4-14**) would use the existing facilities at TRPS.

### 4.10.3 Human Noise-Sensitive Receptors

Noise-sensitive receptors are locations or areas where excessive noise may disrupt normal activity, cause annoyance, loss of business or disturb sensitive ecological habitats. Land uses such as residential, religious, educational, recreational, and medical facilities are more sensitive to increased noise levels than are commercial and industrial land uses.

### 4.10.4 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, no construction activities would occur and noise impacts to nearby human environment would be as it currently exists today.

### 4.10.5 Alternative 3A, Alternative 4, and Alternative 6

Noise impacts during construction, operation, and maintenance of any of the alternatives would occur and would be localized. Noise associated with construction is difficult to predict. Heavy machinery, the major source of construction noise, would be constantly moving in unpredictable patterns.

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, no construction activities would occur and noise impacts to nearby human environment would be as it currently exists today.

Noise impacts during operation, and maintenance of any of the alternatives would occur and would be localized. The in *Noise Study for the Capers Ridge Pump Station* concluded that beyond 500 feet of the pump station the noise generated is the same intensity as background noise. No residential communities are located in close vicinity of the proposed CRPS so that no noise impacts are anticipated to the human environment.

### 4.10.6 Reduction and Mitigation of Potential Impacts

Alternatives 3A, 4 and 6 would comply with local noise ordinances during construction, operation, and maintenance. Provisions would be included in the plans and specifications to require the contractor to make reasonable efforts to minimize construction noise through abatement measures, such as work-hour controls and proper maintenance of equipment muffler systems. Canal conveyance would be subject to routine maintenance during operations involving repair, mowing, vegetation and silt or sediment removal and management. Noise abatement measures for equipment would include noise mufflers. Operational noise would occur during standard, daylight work-hours when such noises are tolerable. It is anticipated that operational noise would be similar to the existing sound environment.

## 4.11 Archeological and Historic Resources

### 4.11.1 Indian Trust Assets

The area directly influenced by Alternative 3A related to Indian Trust Assets includes the proposed location for the Alternative 3A ROW including roads, pipeline, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines.

No areas are identified as Indian Trust Assets within the area of influence for Alternatives 3A, 4 or 6 and therefore no environmental consequences are anticipated for construction, operation, or maintenance of the proposed action alternatives

### 4.11.2 Historic Resources

The area directly influenced by the proposed action alternatives (Alternatives 3A, 4 and 6) for historic resources includes the proposed location for the project ROW including roads, pipeline and/or canal segments, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility, and areas with service utility lines.

Site specific investigations for historic resources were conducted for Alternative 3A. In terms of potential historic resource evaluations for Alternative 4 and 6, site-specific studies were not conducted; however, data maintained by TARL, curated historic USGS topographic maps, the 1936 Harris County General Highway Map, and Google Earth historical imagery were reviewed by licensed archeologists to determine whether the proposed alignments would be present within already identified historic resource areas.

#### 4.11.2.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, no construction activities would occur and there would be no impacts or changes to historic resources

#### 4.11.2.2 Alternative 3A

Based on the investigations conducted described in **Chapter 3.14** and in the above section, two new historic period sites have been identified within the area of potential effect of Alternative 3A. Two areas of potential historic significance in Alternative 3A vicinity were identified and will be avoided by the proposed canal alignment. Although two potentially historic areas are identified within the Area of Potential Effect (APE), no direct effects are anticipated and therefore no environmental consequences are anticipated for construction, operation or maintenance.

The proposed Alternative 3A ROW follows property lines of residential properties and identified historic properties or sites were avoided during project planning and no mitigation is therefore needed for historic resources.

#### 4.11.2.3 Alternative 4

No site specific field investigations were conducted for Alternative 4; however, limited records investigation were conducted as described in **Chapter 3.14** and in the above section. In addition, a review of Texas Sites Atlas electronic records of the Texas Historical Commission was also conducted. This review indicated that no previously recorded historic sites are located within the Alternative 4 ROW alignment.

It is recommended that coordination with the SHPO be conducted in order to avoid and minimize effects to potentially historic resources as a result of the construction of Alternative 4.

#### 4.11.2.4 Alternative 6

No site specific field investigations were conducted for Alternative 6; however, limited records investigation were conducted as described in **Chapter 3.14** and in the above section. In addition, a review of Texas Sites Atlas electronic records of the Texas Historical Commission was also conducted. This review indicated that no previously recorded historic sites are located within the Alternative 6 ROW alignment. However, Agriculture, particularly rice cultivation, has been one of the primary uses of land in the study area, particularly portions of Harris, Liberty, and Chambers counties. The Gulf Coastal Plain is a low-lying geographical area which experiences natural flooding and is well-suited to this crop. Entrepreneurs developed systems of irrigation canals in the early part of the 20$^{th}$ century, which greatly aided rice production. Within the Alternative 6 area, there are few large towns with smaller settlements in the area including New Caney, Eastgate and Huffman. Large-scale rice production required accessible transportation options and improved technology, particularly in irrigation systems and harvesting. Rice canal systems in Texas pumped water from pumping stations on rivers or lakes using centrifugal or vacuum pumps. Steam power or draft animals provided the power to dig canals which ranged in width from 20 to 150 feet. The Dayton Canal along SH 146 in Liberty County has been the subject of intensive-level historic resources surveys and those portions of that canal system that were surveyed were determined to be eligible for listing in the NRHP under Criterion A.

It is recommended that coordination with the SHPO be conducted in order to avoid and minimize effects to potentially historic resources as a result of the construction of Alternative 6. It is anticipated that Alternative 6 may result in permanent, minor effect on cultural resources that may occur during construction. After construction, operation and maintenance of the proposed project would not be expected to affect archeological resources within the Alternative 6 ROW.

## 4.11.3 Archeological Resources

### 4.11.3.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, no construction activities would occur and there would be no impacts or changes to archeological resources.

### 4.11.3.2 Alternative 3A

The area directly influenced by Alternative 3A for archeological resources includes the proposed location for the Alternative 3A ROW including roads, pipeline, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines.

Investigations have been conducted to evaluate the presence of archeological and historic resources within the project footprint in accordance with the technical investigation protocols stipulated by the Texas Historical Commission permit issued for the project. Intensive archeological resource investigations and surveys have been completed. Pedestrian surveys in high probability areas have been conducted for Alternative 3A. Based on the investigations conducted, approximately 30 newly-recorded prehistoric (Native American) archeological sites have been identified within the area of potential effect of Alternative 3A.

Intensive archeological investigations for prehistoric resources have been conducted. Previously identified sites located along Capers Ridge have merged into larger sites and at one or more of these locations, areas of possibly significant deposits have been identified, although these are few in number and localized in extent. Given the knowledge of the terrain, the general character of sites in the upland margin landform, and the erosion and disturbance in the area associated with its logging and agricultural history, it is probable that intact areas of potential significance would be small in size and possible for Alternative 3A to avoid. Prehistoric sites in sandy soils are easily disturbed by tree fall and extensive animal burrowing. It is likely that archeological sites would not exhibit the characteristics that would justify further investigations. The results of intensive pedestrian surveys, supplemental field work, and data review have been compiled and submitted to the THC (Texas Historical Commission) SHPO (State Historical Preservation Officer) for a determination of findings. Through continued coordination with the SHPO, it is anticipated that Alternative 3A would result in permanent, minor effect on cultural resources.

After construction, operation and maintenance of the proposed project would not be expected to affect archeological resources within the Alternative 3A ROW.

### 4.11.3.3 Alternative 4

No site specific archeological investigations were conducted for Alternative 4; however data and records research was conducted as described above. No prehistoric archeological sites have been documented within the Alternative 4 ROW alignment.

However, the Alternative 4 ROW alignment crosses through a wide variety of terrain, including soil types, topography and related environments that are associated with moderate to high probability areas for containing preserved prehistoric sites (including areas that could contain deeply buried sites). For Alternative 4, these areas of potential archeological liability total at least 30 percent of the existing alignment. A pedestrian archeological survey, including shovel testing and/or backhoe trenching where appropriate would be recommended, as needed. Due to the large scale of the project, the remaining low probability areas should be examined for the presence of mapped historic farmsteads, and for limited areas of topography and soils associated with prehistoric occupations that might not be visible at the resolution of the current study. In addition, licensed archeologists consulted for the DEIS recommend at a minimum that a reconnaissance level investigation for the remainder of the alignment, with shovel testing as appropriate, be conducted prior to construction.

It is recommended that coordination with the SHPO be conducted in order to avoid and minimize effects to archeological resources as a result of the construction of Alternative 4. It is anticipated that Alternative 4 may result in permanent, minor effect on cultural resources that may occur during construction. After construction, operation and maintenance of the proposed project would not be expected to affect archeological resources within the Alternative 4 ROW.

#### 4.11.3.4 Alternative 6

No site specific archeological investigations were conducted for Alternative 6; however data and records research was conducted as described above. No historic or prehistoric archeological sites have been documented within the Alternative 6 ROW alignment. However, the Alternative 6 ROW alignment crosses through a wide variety of terrain, including soil types, topography and related environments that are associated with moderate to high probability areas for containing preserved prehistoric sites (including areas that could contain deeply buried sites). The Alternative 6 ROW alignment crosses through two major streams, Cedar Bayou and Gum Gully, and also crosses through the lower Trinity River and San Jacinto River floodplains on the east and west. Archeological resources may be present in the wide floodplain at the western end of the Alternative 6 ROW near Lake Houston. For the Alternative 6 ROW alignment, this route contains four points at which it crosses major streams that would likely require mechanical trenching to prospect for deeply buried sites; these areas of potential archeological liability total at least 30 percent of the existing alignment. A pedestrian archeological survey, including shovel testing and/or backhoe trenching where appropriate, for specific areas identified near streams would be recommended, as needed. Due to the large scale of the project, the remaining low probability areas should be examined for the presence of mapped historic farmsteads, and for limited areas of topography and soils associated with prehistoric occupations that might not be visible at the resolution of the current study. In addition, licensed archeologists consulted for the LIBTP DEIS recommended that a reconnaissance level investigation for the remainder of the alignment, with shovel testing as appropriate, and extensive mechanical trenching in some areas depending on the precise location of the floodplain and other surface water resources be conducted prior to construction.

It is recommended that coordination with the SHPO be conducted in order to avoid and minimize effects to archeological resources as a result of the construction of Alternative 6. It is anticipated that Alternative 6 may result in permanent, minor effect on cultural resources that may occur during construction. After construction, operation and maintenance of the proposed project would not be expected to affect archeological resources within the Alternative 6 ROW.

#### 4.11.3.5 Reduction and Mitigation of Potential Impacts

In accordance with applicable state and Federal regulations designed to provide protection to cultural resources, plans for Alternatives 3A, 4 and 6 include an Unanticipated Discoveries Plan to address unanticipated discoveries subsequent to investigative efforts. The Unanticipated Discoveries Plan would be implemented during construction, maintenance, and ongoing use of the property. The Plan would include a series of requirements and detailed protocol to follow, in addition to an education/information dissemination procedure to raise worker awareness of possible resource discoveries. The Unanticipated

Discoveries Plan would include stop work procedures within the vicinity of the discovery and includes provisions for timely communication to the USACE and the Texas Historical Commission (see **Appendix H** for letter issued by the U.S. Corps of Engineers to the THC dated August 27, 2012). The Unanticipated Discoveries Plan would include a series of procedures involving the presence of the project archeologist during construction, coordination with the respective agencies, possible further evaluation of the resource, determining possible avoidance strategies, and implementing mitigation strategies as applicable.

The possibility of encountering unanticipated cultural remains during construction, maintenance, and ongoing use of a property cannot be precluded, even after investigative survey efforts have been completed. Unanticipated discovery of cultural resources may occur for all proposed action alternatives and would be addressed through implementation of an Unanticipated Discoveries Plan.

## 4.12 Visual and Aesthetics Resources

Title 23 of the United States Code, Section 109(h), requires aesthetic values to be considered during project development. The Council on Environmental Quality regulations for implementing NEPA, (Section 1508.8 – *Effects*), states that aesthetic effects should be considered. Visual resources are defined as natural and man-made features that constitute the aesthetic qualities of an area. Landforms, surface waters, vegetation, and man-made features are the fundamental characteristics of an area that define the visual environment and form the overall impression that an observer receives from an area. Visual resources and proposed changes are evaluated in terms of “visual dominance” and “visual sensitivity.”

Proposed changes in the character of an area can be defined in terms of visual dominance. For example, if the users of the area would overlook the changes to the area’s setting, then the changes would “not [be] noticeable.” If the changes would be noticeable, but would be dominated by other features in the area’s setting, then the changes would be “visually subordinate.” A change that would compete with the visual character of an area is “visually co-dominant.” Finally, a change that would detract from the character of the setting and would demand attention is “visually dominant.”

Visual sensitivity depends on the particular setting in which the proposed action is going to occur. Areas such as coastlines, national parks, recreation areas, and wilderness areas are of high visual sensitivity. In these areas, viewers tend to be aware of even very small changes in the casual environment. On the other hand, in the areas of low sensitivity such as an industrial area, major changes can occur without undue notice to observers.

Visual and aesthetic resources are classified under different formal designation, including national forest, national monument, NWR (National Wildlife Refuge), wilderness area, wild and scenic rivers, national trails, privately owned land, and historic places and districts. Various roads may also be designated as scenic byways due to their scenic, historic, and cultural qualities.

### 4.12.1 Influence Area

The area of potential impact for visual resources includes the geographic area from which Alternative 3A facilities and access roads may be seen. This would generally involve higher elevations and nearby public roadways. No unique aesthetic vegetation, unique natural rock structures, designated scenic areas, parks, statues, historic features and buildings, or administrative sites were identified in the vicinity of the proposed project. Potential aesthetic resources within the project area include water features, roadways, bridges and residences. Water features include the Trinity River, Stoesser reservoir, Reidland reservoir, Luce Bayou, Cedar Bayou watershed, and Lake Houston. Roadway and bridge crossings include SH 321, FM 1008, and FM 2100.

The evaluation of visual and aesthetic resources and potential effects related to the construction and operation of Alternative 3A included the following considerations”.

- Consistency with existing visual character

- Changes in visual quality
- Potential effect on viewers with high viewer sensitivity
- Blockage of sensitive views with an emphasis placed on views that are identified by local jurisdictions as requiring protection
- Creation of shadows
- Light and glare

Changes in visual quality impacts can be low, medium, or high. A high impact is defined as a reduction of the existing visual quality category by one or more of the criteria identified above. For example, if the visual quality category of an area is reduced from high to medium or changes from medium to low, the impact would be considered high. Impacts that are considered low or medium are not evaluated in the assessment of impacts. The impact assessment emphasized areas where changes in the visual environment would be noticed by people with high viewer sensitivity and/or where sensitive views would be affected. For a view to be considered sensitive, it would need to be identified by a local jurisdiction (in comprehensive plans, ordinances, or other directives) as requiring protection or identified during scoping or agency review. The last two items, shadows and light and glare, were assessed by examining engineering plans for likely impacts and examining the visual simulations of project features that were developed.

### 4.12.2 No Action

No construction of new facilities and no property acquisitions that would change the existing visual environment. Under this alternative, the visual environment would remain essentially the same except as changes occur over time at individual properties.

### 4.12.3 Alternative 3A

Although the area is relatively unseen by the public, the proposed pumping facility would interrupt the riparian tree line along the western bank of the Trinity River in the vicinity of the proposed pump intake. The outflow of the proposed canal would also interrupt the riparian tree line along the far bank of the confluence of Luce Bayou and Lake Houston. Segments of the proposed Alternative 3A ROW would traverse properties established as pastureland or used for agriculture; these types of land uses typically have fences and other range improvement structures that potentially detract from the local aesthetic value. In the vicinity of CR 2326, segments of the Alternative 3A ROW transverse or border forested areas. These areas consist of deciduous trees, evergreen trees, or a mixture of both. Individual trees and sections of other wooded vegetation would be removed to accommodate the proposed project, which would aesthetically affect the project area view shed.

Existing pipelines and canals are generally unobtrusive since they are either at-grade (pipelines) or above grade (canals). Other than the proposed pump station and maintenance facilities, there are no proposed elevated structures other than the canal which at some locations may be approximately 3.5 feet above the existing ground level. One section of the canal would be approximately 12 feet above ground level due to the necessity to match the canal to the elevation of two adjacent farming reservoirs. The Alternative 3A ROW would be contained within the 300-foot wide cleared easement owned by the Applicant thereby avoiding impacts to existing structures and improvements.

The proposed maintenance facilities would be located near areas that are currently utilitarian in nature, appearance, and character. This area is categorized as having a low visual quality. The viewer sensitivity for these facilities is categorized as generally local travel along SH 321 for workers (low) and residents (average).

The proposed project would impact the aesthetics of the riparian tree lines at the east bank of the Trinity River in the vicinity of the intake structure and along the bank of Luce Bayou near the confluence of Lake Houston at the discharge location. No impacts to unique aesthetic vegetation, unique natural rock structures, designated scenic areas, parks, statues, historic features and buildings, administrative sites, water features, roadways, bridges, and residences are anticipated as a result of the proposed project.

Alternative 3A would change the visual environment after construction. Project elements would be visible to varying degrees, which could change the visual environment in each specific area. Some of the more potentially visible project components include the elevated canal near the agricultural reservoirs, the pump station structures, maintenance building and parking areas.

Although Alternative 3A would not block sensitive views, project components would be seen by some residents in views that they value. The view of the components would lower the visual quality of views from some individual residences without changing the visual quality category along the proposed Alternative 3A ROW. Alternative 3A would not exhibit effects on the visual environment related to shadows or light and glare with the exception of the potential glare of lights at the CRPS during night operations. If not properly designed and shielded, project-related lighting can create glare impacts and increase the level of ambient light in nearby areas. This would be true during construction and operation. Design-related measures such as shielding and altering light direction would be used where appropriate to reduce potential impacts.

Elevated structures would include the Alternative 3A canal and support structures as well as ancillary equipment that may be elevated above the existing land surface. The elevated structures are anticipated to be the most visible project components. In some locations, the elevated canal may locally intrude on visual resources and the view, although they may not block them altogether. Structures that would be constructed at-grade could be located adjacent to existing roads, pipelines or existing utilities. These structures would be designed to be compatible with the existing roads and adjacent landscape.

A maintenance facility can potentially block views or be viewed down upon from adjacent areas. However, the alternative locations for such a facility are located in areas that already have similar land uses, visual character, and structures. The maintenance facility would be designed to be aesthetically compatible with the surrounding land uses and may involve screening using fencing, walls, or vegetation. During final design, the exterior of the maintenance facility would undergo appropriate design review if required by the local jurisdiction. A parking lot would be located at the maintenance facility along SH 321 and would be constructed of gravel or asphalt. These materials would be low in visual interest. Although not expected, the local jurisdiction could require landscaping that can reduce the visual impact of both the maintenance facility and the parking lot. Local parking lot construction and relevant landscape regulations would be followed to achieve visual compatibility with the surrounding area, as needed.

Removal of vegetation can open up views that are non-existent or, conversely, expose other non-aesthetic views. As possible, the Applicant would preserve existing vegetation, replant vegetation, replace trees, and provide a vegetative screen to minimize effects of vegetation removal.

### 4.12.4 Alternative 4

Although the Alternative 4 intake structure would be relatively unseen by the general public, the proposed CRPS facility would interrupt the riparian tree line along the western bank of the lower Trinity River in the vicinity of the proposed pump intake. The outfall of the proposed pipeline would also interrupt the riparian tree line along the far bank of Lake Houston at the pipeline discharge location. Segments of the proposed Alternative 4 pipeline ROW and elevated easement with access roads would traverse properties established as pastureland or used for agriculture; these types of land uses typically have fences and other range improvement structures that potentially detract from the local aesthetic value. Some areas of construction would require the removal of deciduous trees, evergreen trees, or a mixture of both. Individual trees and sections of other wooded vegetation would be removed to accommodate the proposed project, which would aesthetically affect the project area viewshed.

Typical oil and gas pipelines or other utility lines are are generally unobtrusive since they are either at-grade or below. However, the Alternative 4 pipeline ROW would take the form of an mounded, mowed, cleared and fenced area within a 300-foot easement bordered by access roads and other infrastructure thus resulting in direct, local and permanent effects to the aesthetic environment.

The proposed maintenance facilities would be located near areas that are currently utilitarian in nature, appearance, and character. This area is categorized as having a low visual quality. The viewer sensitivity for these facilities is categorized as generally local travel along SH 321 for workers (low) and residents (average).

Alternative 4 would impact the aesthetics of the riparian tree lines at the east bank of the lower Trinity River in the vicinity of the intake structure and along the bank of Luce Bayou near the confluence of Lake Houston at the discharge location. No additional impacts to unique aesthetic vegetation, unique natural rock structures, designated scenic areas, parks, statues, historic features and buildings, administrative sites, water features, roadways, bridges, and residences are anticipated as a result of the proposed project.

Alternative 4 would change the visual environment after construction. Project elements would be visible to varying degrees, which could change the visual environment in each specific area. Some of the more potentially visible, although low to the ground, project components include the fenced 300-foot wide pipeline easement, the CRPS and associated pumps and structures, maintenance building and parking areas.

Although Alternative 4 would not block sensitive views, project components would be seen by some residents in views that they value. The view of the components would lower the visual quality of views from some individual residences without changing the visual quality category along the proposed Alternative 4 ROW. Alternative 4 would not exhibit effects on the visual environment related to shadows or light and glare with the exception of the potential glare of lights at the CRPS during night operations. If not properly designed and shielded, project-related lighting can create glare impacts and increase the level of ambient light in nearby areas. This would be true during construction and operation. Design-related measures such as shielding and altering light direction would be used where appropriate to reduce potential impacts.

Above-grade electrical supply and associated support structures as well as ancillary equipment may be elevated above the existing land surface. The elevated structures are anticipated to be the most visible, long-range project components although views would not be totally blocked, but impeded to an extent. Structures that would be constructed at-grade could be located adjacent to existing roads, pipelines or existing utilities. These structures would be designed to be compatible with the existing roads and adjacent landscape.

A maintenance facility can potentially block views or be viewed down upon from adjacent areas. However, the alternative locations for such a facility are located in areas that already have similar land uses, visual character, and structures. The maintenance facility would be designed to be aesthetically compatible with the surrounding land uses and may involve screening using fencing, walls, or vegetation. During final design, the exterior of the maintenance facility would undergo appropriate design review if required by the local jurisdiction. A parking lot would be located at the maintenance facility along SH 321 and would be constructed of gravel or asphalt. These materials would be low in visual interest. Although not expected, the local jurisdiction could require landscaping that can reduce the visual impact of both the maintenance facility and the parking lot. Local parking lot construction and relevant landscape regulations would be followed to achieve visual compatibility with the surrounding area, as needed.

Removal of vegetation can open up views that are non-existent or, conversely, expose other non-aesthetic views. As possible, the Applicant would preserve existing vegetation, replant vegetation, replace trees, and provide a vegetative screen to minimize effects of vegetation removal.

### 4.12.5 Alternative 6

Although the Alternative 6 intake structure is relatively unseen by the general public, the existing TRPS facility does interrupt the riparian tree line along the western bank of the lower Trinity River in the vicinity of the pump intake. The outfall of the proposed pipeline would also interrupt the riparian tree line along the far bank of Lake Houston at the discharge location. Segments of the proposed Alternative 6 pipeline ROW and elevated easement with access roads would traverse properties established as pastureland or used for agriculture; these types of land uses typically have fences and other range improvement structures that potentially detract from the local aesthetic value. Some areas of construction would require the removal of deciduous trees, evergreen trees, or a mixture of both. Individual trees and sections of other wooded vegetation would be removed to accommodate the proposed project, which would aesthetically affect the project area viewshed.

Typical oil and gas pipelines or other utility lines are are generally unobtrusive since they are either at-grade or below. However, the Alternative 6 pipeline ROW would take the form of an mounded, mowed, cleared and fenced area within a 300-foot easement bordered by access roads and other infrastructure thus resulting in direct, local and permanent effects to the aesthetic environment.

The proposed maintenance facilities would be located near areas that are currently utilitarian in nature, appearance, and character. This area is categorized as having a low visual quality. The viewer sensitivity for these facilities is categorized as generally local travel along FM 1409 and SH 146 for workers (low) and residents (average).

Alternative 6 does locally impact the aesthetics of the riparian tree lines at the east bank of the lower Trinity River in the vicinity of the intake structure and along the bank of Luce Bayou near the confluence of Lake Houston at the discharge location. No additional impacts to unique aesthetic vegetation, unique natural rock structures, designated scenic areas, parks, statues, historic features and buildings, administrative sites, water features, roadways, bridges, and residences are anticipated as a result of the proposed project.

Alternative 6 would change the visual environment after construction. Project elements would be visible to varying degrees, which could change the visual environment in each specific area. Some of the more potentially visible, although low to the ground, project components include the fenced 300-foot wide pipeline easement, the TRPS and associated pumps and structures, maintenance building and parking areas.

Although Alternative 6 would not block sensitive views, project components would be seen by some residents in views that they value. The view of the components would lower the visual quality of views from some individual residences without changing the visual quality category along the proposed Alternative 6 ROW. Alternative 6 would not exhibit effects on the visual environment related to shadows or light and glare with the exception of the potential glare of lights at the TRPS during night operations. If not properly designed and shielded, project-related lighting can create glare impacts and increase the level of ambient light in nearby areas. This would be true during construction and operation. Design-related measures such as shielding and altering light direction would be used where appropriate to reduce potential impacts.

Above-grade electrical supply and associated support structures as well as ancillary equipment may be elevated above the existing land surface. The elevated structures are anticipated to be the most visible, long-range project components although views would not be totally blocked, but impeded to an extent. Structures that would be constructed at-grade could be located adjacent to existing roads, pipelines or existing utilities. These structures would be designed to be compatible with the existing roads and adjacent landscape.

A maintenance facility can potentially block views or be viewed down upon from adjacent areas. However, the alternative locations for such a facility are located in areas that already have similar land uses, visual character, and structures. The maintenance facility would be designed to be aesthetically compatible with the surrounding land uses and may involve screening using fencing, walls, or vegetation. During final design, the exterior of the maintenance facility would undergo appropriate design review if required by the local jurisdiction. A parking lot would be located at the maintenance facility that may be located along SH 146 or the vicinity and would be constructed of gravel or asphalt. These materials would be low in visual interest. Although not expected, the local jurisdiction could require landscaping that can reduce the visual impact of both the maintenance facility and the parking lot. Local parking lot construction and relevant landscape regulations would be followed to achieve visual compatibility with the surrounding area, as needed.

Removal of vegetation can open up views that are non-existent or, conversely, expose other non-aesthetic views. As possible, the Applicant would preserve existing vegetation, replant vegetation, replace trees, and provide a vegetative screen to minimize effects of vegetation removal.

## 4.13 Federal, State, and Local Requirements

A summary of potential Federal, state, and local requirements for the construction, operation, and maintenance of the proposed Alternative 3A is provided below in **Table 4-24**. Some of the permit requirements referenced were identified during previous planning efforts for Alternative 3A (Bickham 2005; AECOM 2012 **Appendix N**).

**Table 4-24:**
**Summary of Possible Permit Requirements**

| Issuing Entity | Permit | Permit Acquired (Yes/No) | Comments |
|---|---|---|---|
| City of Houston (Houston) and Harris County (HC) | Houston and Harris County/HCFCD Construction Permitting and Storm Water Quality permit | No | Requirements include preparing and submitting Storm Water Quality Management Plan (SWQMP) permit application for construction and post-construction requirements. Application fees are also required. Compliance with TPDES Construction General Permit required.<br>Application(s) will need to be filed prior to construction start. |
| City of Houston (Houston) | Houston authorization for construction of discharge structure into Lake Houston | No | Application to City of Houston will be needed. Based on discussions with City of Houston Permit personnel, will most likely be issued as a Dredge Permit. |
| Department of Homeland Security | Public Drinking Water Supply/Source Protection | No | No specific permitting requirements for the project were identified. However, Department of Homeland Security public drinking water source protection requirements for vulnerability and risk assessment may apply to the project. EPA is designated by Department of Homeland Security as lead agency for Critical Infrastructure and Key Resources. |
| Federal Communications Communication | Possible cell tower relocation | No | Relocation of cell tower **MAY** need to be coordinated with the FCC by the cell tower owner/operator. In 2010, cell tower was located in project right of way. |

| Issuing Entity | Permit | Permit Acquired (Yes/No) | Comments |
|---|---|---|---|
| Federal Emergency Management Agency (FEMA) | FEMA floodplain Conditional Letter of Map Revision (CLOMR)/Letter of Map Revision (LOMR) with USFWS authorization for T&E species/habitat evaluation (if or as needed) | No | FEMA floodplain CLOMR/LOMR will include USFWS review.<br>Application will need to be filed prior to construction start. |
| Federal Energy Regulatory Commission (FERC) | FERC or ENSTOR permit for construction near the ENSTOR Houston HUB & Storage facility | N/A | FERC does not have any permitting requirements that would apply to the LBITP. FERC order issuing certificates of public convenience and necessity was issued April 4, 2008 for the ENSTOR Houston Hub Project. Planned construction completion date is December 31, 2012. Notification to ENSTOR of planned construction project for LBITP recommended. |
| Liberty County | Local authorization from Liberty County for construction activities and building and utilities for maintenance facility and pump station | No | Per County Engineer, the County's Drainage Criteria would apply to the project. County approval will be needed for crossing County roads and the current fee is $2,500 per crossing. The County will need to review the construction plans for the project, the pump station, the sedimentation basin and maintenance facility. Building permit, water well and onsite sewerage facility (OSSF) permit requirements would also apply. The County also has requirements for mitigation for construction in the floodplain. Application(s) will need to be filed prior to construction start. Review of plans by Liberty County Engineering and Permit Department will be required. |
| Liberty County and Harris County | Platting and deed recordation for property owned by CWA | No | File platting and deed records with County Clerk's Offices. |
| Sam Houston Electrical Cooperative (SHECO) | Electrical Service Lines | No | SHECO has applications process for service. Recommend initiate discussion with SHECO as to what will be needed for electrical service to LBITP facilities. |
| Texas Commission on Environmental Quality (TCEQ) | Public Drinking Water Supplies (Chapter 290) | No | No specific permitting requirements identified for the construction phase of the project related to TCEQ Public Drinking Water Supply Chapter 290 Rules. Chapter 290 Rules apply to the drinking water purification plant, particularly any expansion or modification. |
| Texas Commission on Environmental Quality (TCEQ) | TCEQ Section 401 State Water Quality Certification | No | TCEQ will conduct 401 State Water Quality Certification review as part of the Section 404 Permit Review process. |
| Texas Commission on Environmental Quality (TCEQ) and various agencies | Water Rights Permit (Texas Water Code Chapter 11, Texas Administrative Code Chapters 288, 295, 297) | Yes | Water Rights permits have been obtained and are issued to City of Houston. Water Use Permit No. 5826 and Certificate of Adjudication 08-4621, as amended. |

| Issuing Entity | Permit | Permit Acquired (Yes/No) | Comments |
|---|---|---|---|
| Texas Commission on Environmental Quality (TCEQ) | Texas Pollutant Discharge Elimination System (TPDES) General Number TXR150000 Relating to Storm Water Discharges Associated with Construction Activities (Construction General Permit) | No | Prepare Storm Water Pollution Prevention Plan (SWPPP) and Notice of Intent (NOI). Submit NOI and fee to TCEQ prior to beginning of construction activities. Include SWPPP requirements in contractors' bid packages. Application will need to be filed prior to construction start. |
| Texas Commission on Environmental Quality (TCEQ)/ Texas Parks and Wildlife Department (TPWD) | TCEQ/TPWD Bed and Banks permit for Trinity River and Lake Houston | No | Bed and banks authorization needed if project will transport water using a state watercourse. Reviewed as part of TCEQ's water rights permitting process. |
| Texas Department of Agriculture (TDA) | Agricultural issues consultation | No | Agency review of prior converted cropland and prior converted wetlands from TDA as well as USDA/NRCS. Agency reviews for LBITP will be needed. |
| Texas Department of Transportation (TxDOT) | TxDOT permit and easements within and for roadway crossing construction. ROW and Transportation access. | No | TxDOT has application process for Utility Installation (Utility Installation Request Form 1082). TxDOT also has other requirements that will apply to the project (e.g., signage, barriers, temporary road closures, traffic control).<br>Application will need to be filed prior to construction start. |
| Texas General Land Office (GLO) | GLO Miscellaneous Easement for state-owned lands and waterways | No | The GLO has authority to grant easements for rights of way across navigable waterways or state-owned lands and stream beds. GLO charges fees for such easements. Per GLO, state may consider reduced easement fees since LBITP is a public works type project. Recommend contacting GLO to discuss project. Application will need to be filed prior to construction start. |
| Texas Historical Commission (THC) | Cultural Resources (SHPO/Section 106 Review) | No | Archeological Investigation conducted under Archeology Permit No. 5082. Archeological resources were identified. A plan to address potential archeological resources will need to be developed and approved by state and federal agencies. |
| Texas Parks and Wildlife Department (TPWD) | Texas Parks and Wildlife Department Revenue Sand Permit | No | If the stream is perennial (flows most of the time), or is more than 30 feet wide between the banks (even if it is dry most of the time), the State claims the bed and the sand and gravel in it as State-owned. A permit from the Texas Parks and Wildlife Department is required to "disturb or take" streambed materials from a streambed claimed by the State.<br>An application must be filed with the Department, including information on the size of the stream, the nature of the banks and the bed of the stream, the amount of material to be disturbed or removed, the adjacent landowners, and the probable effects on the stream and its other users. A fee, ranging from $250 to $1200 must accompany the application. The Department evaluates the probable impact to the environment of the activity, and grants a permit if no significant damage is anticipated. Individual permit applications require a hearing before the permit is issued. |

| Issuing Entity | Permit | Permit Acquired (Yes/No) | Comments |
|---|---|---|---|
| Texas Public Utility Commission (PUC) | Texas Public Utility Commission electrical power distribution system installation permit | No | Recommend CWA initiate discussions with SHECO regarding electrical service. |
| Texas Railroad Commission (RRC) | Authorization for construction near oil and gas wells (if needed) | N/A | RRC does not have specific permitting requirements that would apply to the LBITP. Notification to affected property owners/operators recommended. |
| Texas Water Development Board (TWBD) | Environmental Review | No | Environmental review is part of the TWBD funding process. TWBD will review and adopt the USACE Record of Decision. |
| United States Army Corps of Engineers (USACE) – Galveston District | Permit under Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act | Yes | USACE 404 Permit application has been submitted and is in progress (SWG-2009-00188). New requirements for stream impact and mitigation may affect the project. This should be addressed as part of the 404 review process.<br>Invasive species management may need to be addressed for the project. |
| United States Department of Agriculture (USDA)/Natural Resource Conservation Service (NRCS) | Agricultural issues consultation | Yes* | *TBD; Prior converted cropland determination. Agency review of prior converted cropland and prior converted wetlands will be needed. Land use changes will trigger possible additional review. Authorization for impact to prime farmland soils may also be needed, if applicable. |
| United States Fish and Wildlife Service (USFWS) | Golden and Bald Eagle Protection Act<br>Migratory Bird Treaty Act<br>Endangered Species Act | No | No adverse efforts on these species are anticipated. These species may utilize areas near the project for feeding and nesting.<br>No federally listed threatened or endangered (T&E) species have been identified for the project. In the event that T&E species may be affected during the course of the project, a permit for “incidental taking” may be needed. |
| United States Environmental Protection Agency (USEPA) | USEPA Clean Water Act Requirements | No | EPA review will be conducted as Part of Section 404 Permit Review process. If all the construction is within Texas, State TPDES permits should cover activities, unless on Indian Lands. No Indian lands have been identified for the project. |
| Various pipeline owners/operators | Authorizations from pipeline owners/operators with project crossings | No | Authorizations from pipeline owners or operators for project crossings. |

## 4.14 Climate Change

Texas’s climate is strongly influenced by three large geographical features, the Rocky Mountains, the central and eastern North American continent, and the Gulf of Mexico (UT Press 2011). The climate of Galveston Bay area is subtropical, with winds which are typically out of the southeast with an average speed of 10-15 miles per hour (NOAA 2012a), mean daily temperatures range from approximately 50 degrees Fahrenheit in January to approximately 83 degrees Fahrenheit in July and August, and with an average rainfall of approximately 53 inches, with monthly precipitation averaging from approximately 3 to 6 inches (RSS Weather 2012; NOAA 2009b).

The EPA defines climate change "as distinct change in measures of climate lasting for a long period of time" (EPA 2009). Climate records in Texas go back more than a century, however climate projection is inherently difficult to identify for a small sub-area of the globe than for the globe as a whole. This is particularly true for Texas whose climate changes throughout the year. Partially because of this complexity, climate variations over the past century in Texas do not correspond to changes expected from global warming, according to present day climate models (UT Press 2011). Due to the complexity of identifying true climate change, rather than natural climate fluctuations, scientists often look towards more measurable indicators to help determine possible climate change.

The EPA identifies climate change indicators as including "(changes in) temperature, precipitation, sea level, and greenhouse gas concentrations in the atmosphere" (EPA 2012a). The following is an overview of the impacts that climate change could have on air quality in Texas and the challenges that this poses. This is followed by a discussion of ozone air quality conditions in the Harris-Galveston-Brazoria air quality region and the relationship to temperature. The report concludes with a discussion of adaptation opportunities and constraints for the air quality planning process.

### 4.14.1 Climate Change and Regional Air Quality

A changing climate will likely make it more difficult to meet air quality standards, particularly for ozone. The "climate penalty" is associated with the additional emission reductions and associated costs required to meet air quality standards in face of climate change. Programs to reduce greenhouse gas emissions must be considered in conjunction with efforts to meet air quality standards when these goals conflict.

### 4.14.2 Air Pollution and Climate Change

Analyses of the effects of climate change on air pollution have shown that climate change is likely to lead to an increase in the severity and duration of air pollution episodes (Mickley et al. 2004; Mickley 2007). Air pollution levels can be affected by several direct and indirect effects of climate change: (i) increased temperature, (ii) changes in biogenic emissions (e.g., emissions from vegetation), (iii) changes in chemical reaction rates, (iv) changes in atmospheric conditions that affect pollutant mixing, and (v) changes in the atmospheric flows that affect pollutant transport (Hogrefe et al. 2004). In addition, behavioral responses to climate change could result in an increase in emissions, for instance through increased energy demand during heat-waves (Franco and Sanstad 2008). There are also feedbacks between air pollution and climate change, as some local air pollutants also have an effect on the climate. Most studies have focused on the impact of climate change on ozone levels, though some analyses have also focused on particulate matter.

### 4.14.3 Ozone

Ozone is not emitted directly, but is formed in the atmosphere through a series of chemical reactions involving hydrocarbons and oxides of nitrogen (NOx) that are driven by sunlight. The production of ozone is highly non-linear; it depends on meteorological conditions as well as local concentrations of ozone precursors. Reductions in either NOx or hydrocarbon emissions could result in an increase in air pollution, depending upon local conditions.

Ozone is likely to be sensitive to changes in temperature, mixing depths, the frequency in stagnant air episodes, and changes in weather patterns as a result of climate change (Mickley et al., 2004). In addition, ozone levels are sensitive to changes in biogenic emissions (Bell and Ellis, 2004; Steiner et al., 2006). Studies have found that the cumulative effects of these factors are complex and vary by region (Hogrefe et al., 2004; Mickley et al., 2004; Leung and Gustafson, 2005; Steiner et al., 2006; Bell et al., 2007; Mickley, 2007; Tagaris et al., 2007). For example, one analysis predicts that climate change will have a negative impact on air quality in Texas, while there will be a negligible or positive impact on air quality in the Midwest (Leung and Gustafson, 2005). Most of these analyses do not account for future changes in the emission levels (i.e., the emission inventory). Therefore, while they provide an estimate of the effect of climate change assuming current levels of criteria pollutant emissions, they are not likely to be representative of future conditions in terms of emissions and growth.

Another factor that influences ozone concentrations over the long-term is the level of the global background ozone concentration—the concentration of ozone that would exist in the urban areas of the United States without anthropogenic (or human-caused) emissions. The concentration of background ozone in the United States appears to be increasing (Lin et al., 2000). The sources of background ozone are primarily natural production and transport from regions outside the United States (Asia and Europe).[29] If emissions continue to increase in developing countries as predicted, the contribution of background ozone concentrations to local air pollution levels in the United States will likely increase (Fiore et al. 2002a). Increases in global background ozone concentrations could prolong the ozone season in the United States (Fiore et al., 2002b). On balance, the increase in global background ozone levels will reduce the effectiveness of local emission reduction measures making it more difficult to attain air quality standards (Lin et al., 2000; Fiore et al., 2002a; Fiore et al., 2002b).

#### 4.14.3.1 Climate Impacts on Ozone Concentrations

Several analyses have found that climate change could increase ozone levels in Texas. Meteorology and, specifically, temperature have a large influence on ozone levels in the state. One such analysis, looking at high ozone episodes under past conditions, shows that higher temperatures, increased background ozone levels, and increased mixing depths—all phenomena expected with climate change—generally increased surface ozone concentrations (Kleeman, 2008).[30]

The reduction in the estimated improvements in future air quality as a result of climate change is known as the "climate penalty" (Mickley, 2007). To attain air quality standards in the future, additional emission reductions will be required beyond those predicted using historical meteorological conditions, which is standard practice in air quality planning today.

### 4.14.4 Particulate Matter

Fewer studies have examined the effect of climate change on PM pollution levels than on ozone levels. PM can be emitted directly, but is also formed in the atmosphere through a series of reactions that involve a variety of compounds including, NOx, ammonia, and sulfates. The effects of climate change on PM concentrations are difficult to determine because there are a number of interactions at work. A recent analysis suggests that climate change will likely increase fine PM concentrations, but more work is needed.

There is not a one-way relationship between climate change and air pollution. Ozone is itself a greenhouse gas, and increases in ozone levels in the lower atmosphere have contributed to global warming. It is estimated that increases in ground-level ozone since the pre-industrial era have contributed one-fourth to one-third of the warming effect of carbon dioxide (Forster et al. 2007; Mickley 2007). Therefore, reducing ground-level ozone levels could result in climate benefits.

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29 The contribution from the upper atmosphere appears to be negligible (Fiore et al. 2002a). It is important to distinguish between ozone in the lower atmosphere (tropospheric ozone) and the ozone layer (stratospheric ozone). In the troposphere, ozone is a pollutant that has negative impacts on human health. Air quality standards are set to limit the levels of tropospheric ozone. Stratospheric ozone, on the other hand, forms a protective layer in the upper atmosphere that protects the earth from the sun's harmful rays. Significant efforts have focused on protecting the stratospheric ozone layer and reducing the "ozone hole."

30 This analysis is known as a "perturbation study," which allows re-analysis of past high ozone episodes, with adjustments of individual meteorological variables using complex air quality models.

The relationship between PM and warming, on the other hand, is more complex. Some particulate matter, specifically black carbon (soot) from combustion (largely from diesel engines) contributes to global warming (Jacobson 2002). Therefore, reducing black carbon levels could have a positive climate effect. On the other hand, other components of particulate matter, such as sulfates, have a net cooling effect. These aerosols reflect incoming solar and infrared radiation and affect cloud formation (Forster et al. 2007). Modeling has shown that an abrupt reduction in aerosol concentrations could enhance warming (Brasseur and Roeckner 2005). Therefore, particulate matter poses an interesting challenge—from a public health standpoint, its reduction is necessary, but in some cases this reduction could aggravate global warming.

## 4.14.5 Extreme Events

Poor air quality is often correlated with the occurrence of certain extreme events. Extreme heat events, defined as days with temperatures above the 90th percentile (T90) for a baseline period, occur about a total of six weeks a year (Drechsler et al. 2006) in Texas. The increased likelihood of violating air quality standards with higher temperatures results from a combination of factors. One contributor is the increase in emissions associated with higher energy use on high temperature days (Franco and Sanstad 2008). Analysis of power plant $NO_x$ emissions with temperature at several locations around the state shows a roughly 3 percent linear increase in NOx emissions from power plants per degree F increase in daily maximum temperature. Another extreme event that can affect air quality is wildfire. Wildfires can lead to increased concentrations of particulate matter. Climate change is predicted to alter the characteristic and extent of forests and increase the risk of wildfires (Cayan et al., 2006; Westerling and Bryant, 2006).

## 4.14.6 Ozone Air Quality in Texas

The National Ambient Air Quality Standards (NAAQS) established for ozone and the other five criteria pollutants are designed to be protective of human health. The EPA revised the NAAQS for ozone, making it more stringent and protective (USEPA 2008b). HGB air quality region and the Houston-Galveston-Brazoria area are responsible for preparing a State Implementation Plan (SIP), which shows how all regions of the state will come into compliance with the NAAQS.

The ozone season in Texas typically spans from May to September, as high ozone concentrations tend to be associated with warmer weather (Lin et al. 2001). Using air quality data, the relationship between temperature and the probability of exceeding the federal eight-hour ozone standard during the ozone season was evaluated. There is a statistically significant, positive relationship between temperature and the probability of exceedance of the ozone NAAQS. Data and studies have demonstrated that an increase in high temperature days could likely result in an increase in exceedances of the ozone standard.

## 4.14.7 Air Quality Planning and Climate Change

Air quality planners face two primary challenges from climate change: reduction in future air quality improvements (the climate penalty) and increased incidence of extreme events that result in more unhealthy air days. At the local level, the focus remains on meeting air quality standards. From the standpoint of public health, it is important not to divert attention and limited resources from the primary goal of improving air quality, given the public health impacts of current poor air quality. Nonetheless, local air quality regions should become aware of the relationship between air quality rules and regulations and climate change in order to insure that public health goals can still be met as the climate changes.

Examination of poor air quality episodes that occur under extreme conditions can allow decision-makers Under a changing climate, it is likely that additional emission reductions will be needed to overcome the climate penalty. If the distribution of emission sources remains similar to the current distribution, this could pose a challenge to local air districts because they do not have authority over the majority of emissions. Attainment will require large reductions from sources that fall under state and federal authority, notably “mobile source” emissions (e.g., from cars and trucks). Creative measures may need to be taken to reduce emissions from mobile sources.

### 4.14.8 Federal Planning Process Constraints

The final constraint on agencies working to incorporate climate change into air quality planning is the bureaucratic and constrained federal requirements for developing and approving SIPs. A recent review of air quality management by the National Research Council (NRC) (2004) found that while the SIP process has likely been helpful in improving air quality, it has not led to many regions coming into attainment with the NAAQS. In addition, the review committee found that the process is overly legalistic and bureaucratic and likely stifles innovation and experimentation. The committee also found that the attainment demonstration process creates a sense of security that may also fail to account for significant uncertainties that could affect attainment of the NAAQS.

Understanding air quality impacts under extreme events would help local air quality planning agencies to be prepared to face a changing climate. The current process provides no incentive to quantify this uncertainty and is constructed around a deterministic, rigid modeling process. Increasing frequency of extreme events could also make episodic control programs attractive. In the longer-term, it could be beneficial to integrate air quality planning for criteria air pollutants with planning to reduce greenhouse gas emissions. This could enable the full incorporation of feedbacks between air pollution and global warming and the consideration of potential conflicts between emission reduction strategies. The current federal air quality planning process is not compatible with this approach.

### 4.14.9 National Ambient Air Quality Standards (NAAQS)

The Clean Air Act directs the EPA, in coordination with state and local agencies, to improve air quality, and it directs EPA to set the NAAQS. The NAAQS set limits for six air pollutants known as criteria air pollutants: ozone, carbon monoxide, nitrogen dioxide, lead, particulate matter, and sulfur dioxide. Of these, ozone and particulate matter cause the most widespread pollution problems in the country. The primary standards are set to be protective of human health. In addition, for some criteria pollutants, there are secondary standards set to limit environmental and property damage. For example, ozone can damage agricultural crops and building materials. Areas that are designated to be in non-attainment are required to demonstrate compliance with the primary standards and must develop a plan demonstrating the emission reduction strategies that will be employed to come into attainment with the standards. Each region is given a deadline by which to meet the standards, with later deadlines for basins where the air quality problem is more severe. Failure to meet these standards can result in sanctions by the federal government, notably the loss of federal highway funds.

### 4.14.10 Temperature

The most direct manifestation of global warming is a rise in surface temperatures. Local temperature changes are significant for agriculture, ecosystems, energy use, water supply and other aspects of the Texas economy and way of life. It is recognized that local temperature changes, even over decades to centuries, may be strongly influenced by changes in regional climate patterns and sea surface temperature variations (UT Press 2011). **Figure 4-15** shows average winter temperatures in Texas over a hundred year time span while **Figure 4-16** shows the average spring/fall temperature and **Figure 4-17** shows the average summer temperatures in Texas for the same time period. **Figure 4-18** shows average temperatures in Galveston, Texas during an average year.

**Figure 4-15:**
**Average Winter Temperatures in Texas 1901-2000**

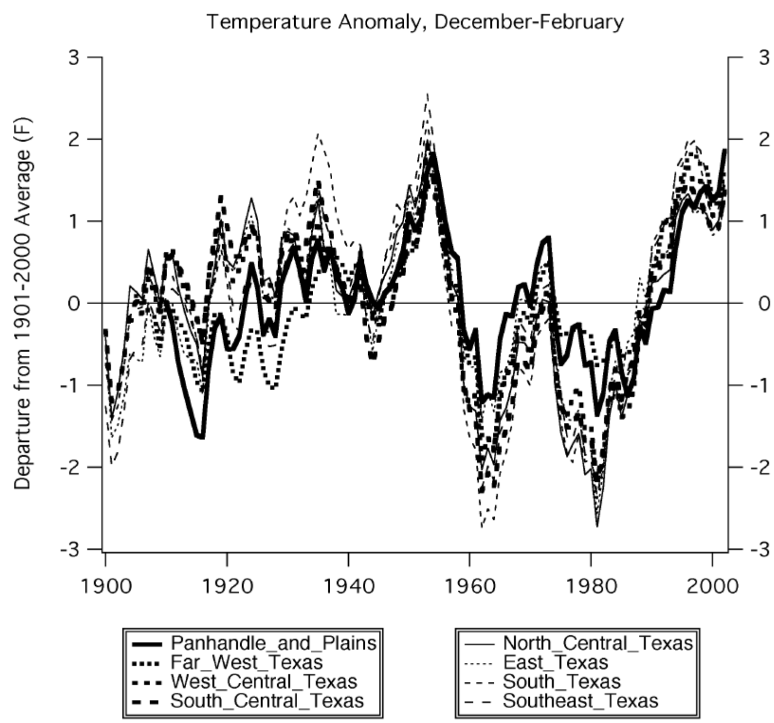



**Figure 4-16:**
**Average Spring/Fall Temperatures in Texas 1901-2000**

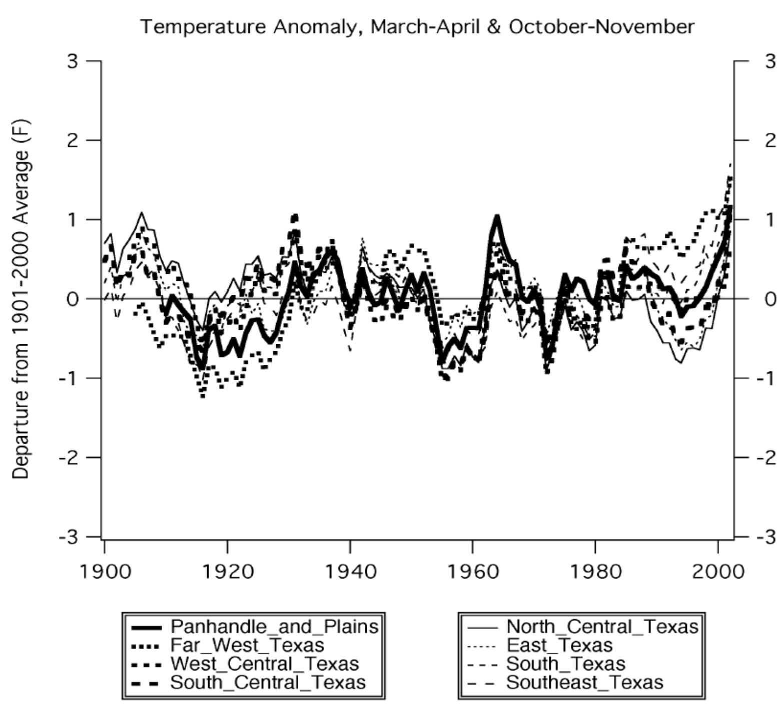
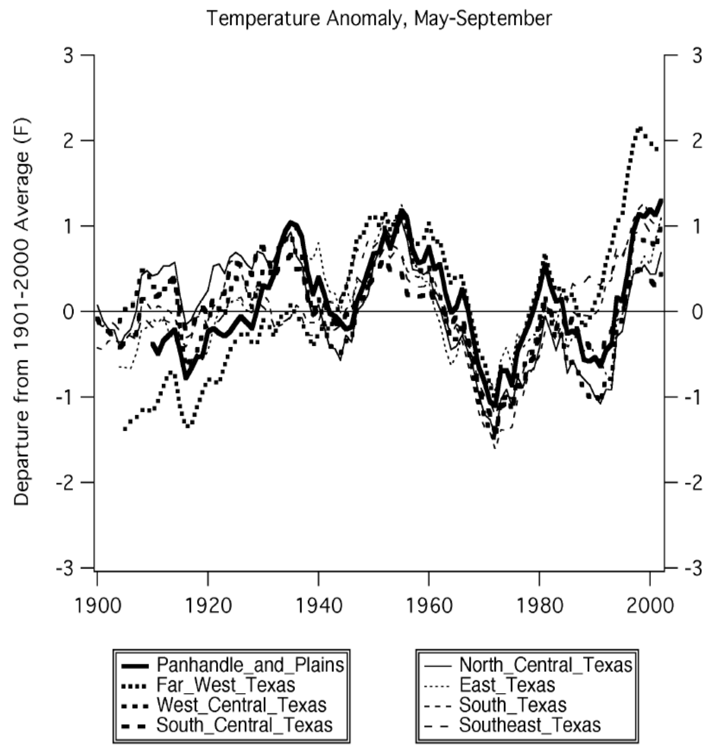


**Figure 4-27:**
**Average Summer Temperatures in Texas 1901-2000**



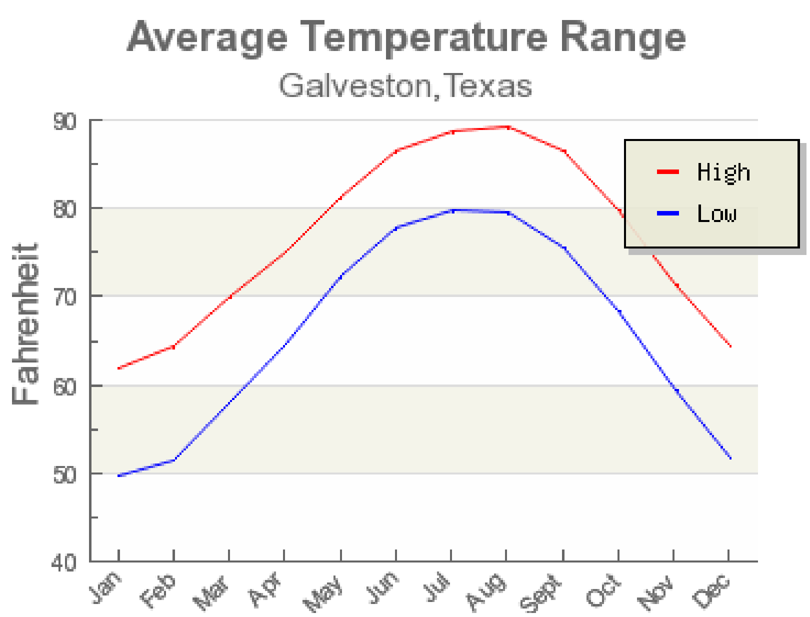




**Figure 4-38:**
**Average Temperatures in Galveston, Texas**

If the temperature observations are taken at face value, temperatures across Texas have increased fairly steadily over the past 20 to 30 years. However, this temperature increase began during a period of anomalously cold temperatures and it is only during the last 10 to 15 years that temperatures have become as warm as during earlier parts of the 20th century (UT Press 2011).

### 4.14.11 Precipitation

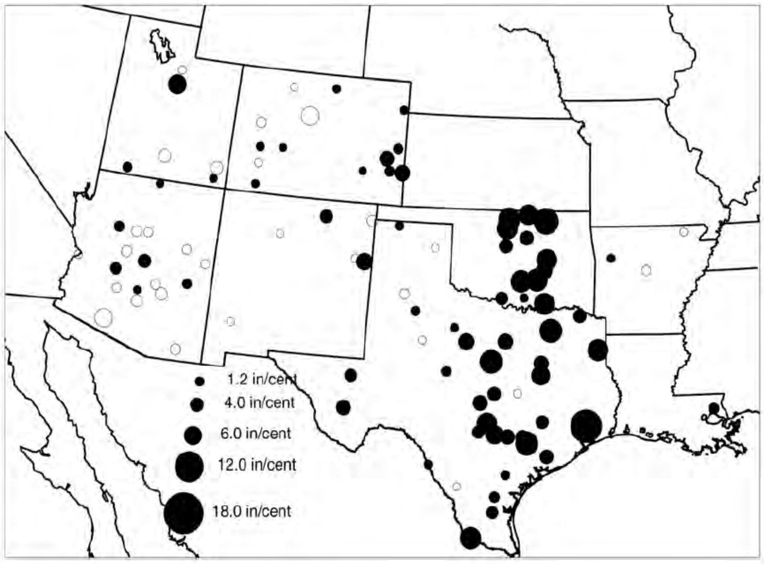
Texas climatologists have records that indicate the 2011 drought is the worst one-year drought in Texas history (since rainfall started being recorded in 1895) and has been described as a 500 year drought event (Stermolle 2011 http://www.jsg.utexas.edu/ciess/files/Water_Forum_01_Stermolle.pdf). The previous standard for an one-year drought, 1925, can only be considered the worst ever in 14.6 percent of the state. In July 2011, the statewide Palmer Drought Severity Index, which is a measure of dryness that includes both temperature and moisture, recorded its lowest ever reading, surpassing the worst July readings for 1918, 1925, and 1956, the droughts of record in Texas. Though water planning in Texas *is* drought planning, the system has not been truly tested, until now, in a major drought. Almost all of the steam-electric cooling lakes were built after the 1950s drought. The dependency of Texas electric generation on the maintenance of water level in the State's reservoirs does not seem to be given adequate consideration in water planning. Though power generation is a significant consumer of water, a minimum water elevation is necessary, both to allow pumping of the cooling water, and to prevent heating of the reservoir and reduced efficiency of generation. In the last two decades, several power plants have been forced off-line because of either low water levels or high intake temperatures, but these have been spasmodic and easily accommodated with the redundancy of the grid. As we have seen, in 2011, the large-scale drought with widespread reduction in reservoir levels did endanger the State's generating capacity with the result that rolling blackouts ("brownouts") occurred periodically during the summer of 2011.

A water quality variable that may be affected by the flow regime and may influence aquatic life includes dissolved oxygen. Historically, anoxia and hypoxia (low dissolved oxygen) in the upper Trinity River below Fort Worth and Dallas have caused major declines in fish and aquatic organism populations. Water quality has steadily improved since the mid-1980s and the incidence of hypoxia is currently low. Violation of dissolved oxygen criteria is the most common reason for not supporting aquatic life uses in the Trinity River based on the most recent state water quality assessment reporting. The relationship of stream flow and dissolved oxygen is variable. During the period before the mid-1980s when wastewater treatment was insufficient, anoxic water was often associated with rising water levels. Based on recent analyses of historical water quality and flow data, it appears that low dissolved oxygen is usually geographically oriented around developed portions of the watershed (near Dallas Fort Worth) and/or occurs more frequently at lower flows. Instream flows are not the only factor affecting dissolved oxygen levels since point and non-point source loading (e.g. wastewater facilities, storm water, agriculture) of organic pollutants can exert a strong influence on dissolved oxygen dynamics and must ultimately be controlled through best management practices and permitting (Hersh and Maidment 2006).

In the upper Trinity River basin, winter water temperature and flow does not vary appreciably; however higher flows during other months generally resulted in declining water temperatures at the Rosser gauge (08062500). This relationship was strongest during the summer months. Dissolved oxygen exhibited similar seasonal responses to increasing flows with greatest increases occurring in the summer months. Short-term increases in nutrient concentrations may occur after storm events as surface water flows enter the watershed relatively rapidly (Environmental Institute of Houston 2009).

Precipitation is not expected to increase significantly over time (UT Press 2011). However, over the last one hundred years, within the Galveston Bay area, precipitation has increased an average of 20 percent (see **Figure 4-19**).

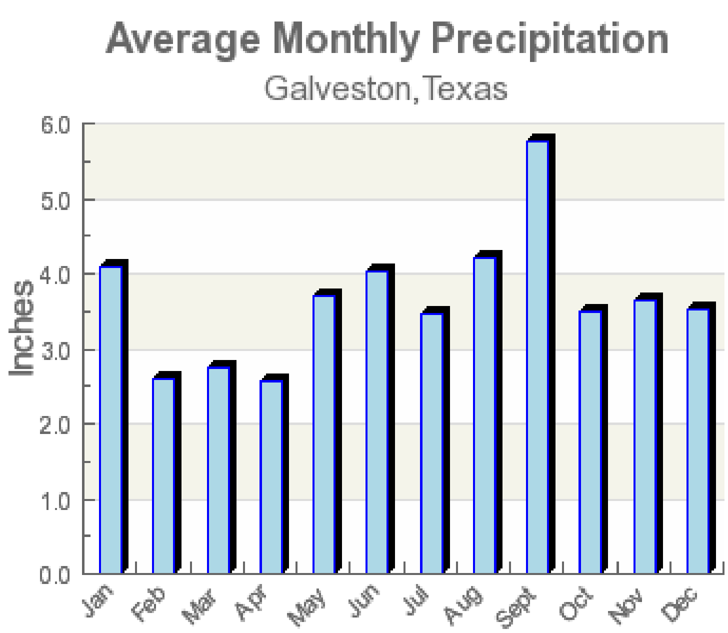
**Figure 4-49:**
**Texas Precipitation in Inches per Century**




Precipitation trends in inches per century.
Solid circles represent increases; open circles represent decreases.

Based on a recent study, the driest month of the year in Galveston is April with 2.56 inches of precipitation; while September is the wettest month with 5.76 inches (RSS Weather 2012). **Figure 4-10** shows average monthly perception in Galveston.

**Figure 4-20:**
**Average Monthly Precipitation in Galveston, Texas**

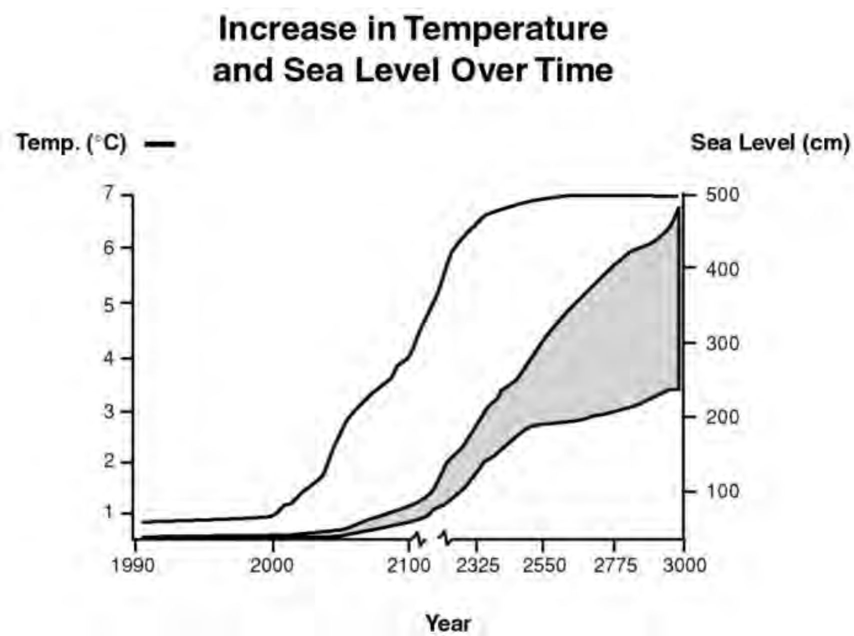


### 4.14.12 Sea Level

It has been estimated that more than 100 million lives are potentially impacted by a one-meter increase in sea level (NASA 2005). The United States Army Corps of Engineers (USACE) stipulated that impacts to coastal and estuarine zones caused by sea-level change must be considered in all phases of Civil Works programs (USACE 2009).

Increases in average temperatures are expected to raise sea level by expanding ocean water, melting mountain glaciers and small ice caps, and causing portions of the Greenland and the Antarctic ice sheets to melt (EPA 2012b). **Figure 4-21** shows anticipated sea level rise and relating temperature increased over time.

**Figure 4-25:**
**Increase in Temperature and Sea Level Over Time**




Sea level curves show the range of uncertainty given the trend for temperatures. The temperature curve starts at 0.5°C to account for past warming due to greenhouse gases.

Along the coast, and around the world, sea level is rising 5 to 6 inches more than the global average along the Mid-Atlantic and Gulf Coasts in the last century; this effect is due to coastal lands that are subsiding (EPA 2012b).

Tide gauge records in south Texas which include the effects of land subsidence, show that relative sea level has risen at a rate of 4.6 mm/y (0.18 inches/year) at Rockport (since 1948), 2.05 mm/y (0.08 inches/year) at Port Mansfield (since 1963), and 3.44 mm/y (0.14 inches/year) at South Padre Island (since 1958) (UT Press 2011). Sea-level rise rates along the Texas coast are high because of subsidence, which causes the relative rise to be that much greater (UT Press 2011).

### 4.14.13 Greenhouse Gases

The warming of the Earth is directly related to the atmospheric concentration of greenhouse gases. Greenhouse gases refer to gases that trap heat in the atmosphere. The principal greenhouse gases that enter the atmosphere because of human activities are carbon dioxide ($CO_2$), methane ($CH_4$), Nitrous Oxide (N2O), and fluorinated gases (UT Press 2011; EPA 2012c).

The most prominent of the greenhouse gases is carbon dioxide.  Carbon dioxide enters the atmosphere through the burning of fossil fuels (oil, natural gas, and coal), solid waste, trees and wood products, and as a result of other chemical reactions (e.g., manufacture of cement).  Carbon dioxide is sequestered from the atmosphere when it is absorbed by plants as part of the biological carbon cycle (UT Press 2011; EPA 2012c).

Methane is a naturally occurring gas that makes up approximately 18 percent of the current greenhouse gas contribution for human activity. Methane is emitted during the production and transport of coal, natural gas, and oil and also results from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills (UT Press 2011; U.S. EPA 2012c).

Nitrous oxide is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.  Nitrous oxide as a global warming contributor has declined from 4.5 percent of total carbon-equivalent emissions in 1990 to 2.7 percent in 1999 (UT Press 2011 and EPA 2012c).

Fluorinated gases include hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. Fluorinated gases are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes and are sometimes used as substitutes for ozone-depleting substances (i.e., CFCs, HCFCs, and halons) (UT Press 2011; EPA 2012c).

## 4.14.14 Climate Change and the LBITP

This discussion draws heavily on observations and considerations to be found in the following source material:

- *Understanding Sea Level Rise and Variability*, edited by Church, Woodworth, Aarup, and Wilson, Wiley+Blackwell publishers , 2010
- USACE Engineering Circular (EC) 1165-2-211, 2009
- Intergovernmental Panel on Climate Change, various work products including *Climate Change 2007: The Physical Science Basis*, February 2007
- U.S. Geological Survey Climate Change Science , various work products including those on climate change in the lower Mississippi Valley
- *Uncertainty, Climate Change, and Adaptive Management* Conservation Ecology online www.consecol.org/

Harris and Liberty counties are located in a region which has been and will continue to experience extensive effects from urbanization, large scale surface water demands, and related management issues, and from the introduction of exotic species.  The effects of changes in climate on freshwater ecosystems including riverine systems may be accentuated by these human induced stressors.

While there are uncertainties concerning how climate might change in the study area, some assumptions can be made concerning the types of changes that might occur in area aquatic ecosystems.  These assumptions are based on predictions that mean temperatures are likely to rise and alterations to the hydrological cycle are expected to occur.  As one example, mean temperature increases of 3 to 5 degrees Celsius are predicted from various General Circulation Models based upon a 2X $CO_2$ scenario. Such models attempt to simulate the physical processes that determine global climate.  The scenario used in this discussion is one which simulates climate based upon a doubling  of atmospheric $CO_2$.. Some model results predict potential increases in precipitation and that the hydrologic cycle may be intensified.  This suggests changes in the frequency of weather events such that increases in hurricane frequency could occur, rain events more clustered in time, and summer drought periods more common.

Changes in climate features such as those just mentioned would have consequences for the study area. A general warming in the area would lead to longer growing seasons which may increase net primary productivity in wetlands. Organic matter decomposition would likely increase with rising temperatures which would intensify biogeochemical cycling and increasing emissions of $CO_2$ and $CH_4$ (methane). Higher air temperatures would increase evapotranspiration and reduce rainfall runoff. ncreases in summer maximum temperatures in impoundments, reservoirs and larger rivers would reduce habitat for fish with low tolerance for higher water temperatures. Warmer water temperatures would stress these species and cause them to be more susceptible to pathogens and parasites. Increased demand for electricity in summer periods could result in increased waste heat discharges to many waters thus exacerbating already high summer water temperatures. Increases in winter air temperatures could cause the expansion of sub-tropical species northward from their present limits in Mexico. Species such as the wetland plant *Melaleuca quinquenervia* (Paperbark tea trees) could become established. This species proliferates into dense forest stands and virtually eliminate other vegetation.

The increased duration of summer droughts is another critical climate feature that could occur in the study area under the example climate scenario. Droughts limit habitat through reduction in dissolved oxygen concentration, degrade water quality, and can potentially limit the seasonal flooding of some wetland communities increasing their susceptibility to fire.

The size and duration of rain events control erosion and sedimentation stresses as well as nutrient inputs to freshwaters. Under the example climate scenario, increased storm size and frequency are predicted which would lead to higher peak stream flows thereby increasing sediment loads leading to reduced habitat for stream fish and many invertebrates. These effects would be overlapping the effects of increased sediment loads and habitat loss (stream channel modifications) due to urbanization. Greater runoff from urban and agricultural lands due to intensified rain events would increase nutrient inputs and toxic substances to freshwater areas. Depending upon overall changes to the water balance, wetland areas could increase in size, although present and future land use practices (such as those evident in the Cedar Bayou watershed) might prevent such a response. If river flows increase, estuarine flushing rate could increase.

## 4.15 Energy Requirements and Conservation Potential

The area directly influenced related to energy requirements and conservation potential includes the proposed location for the Alternative 3A ROW including roads, pipeline, canal, pump and discharge stations, sedimentation basin, proposed mitigation property, maintenance facility and areas with service utility lines. **Figures 4-22**, **4-23** and **4-24** provide exhibits showing electrical corridors and other crossings for each proposed action alternative.

Energy, in the form of various fossil fuels, would be required during any construction, operation, and maintenance of the proposed water supply project. At this time, prior to the development of the final detailed design plans and specifications, it would be difficult to determine the specific energy requirements for the construction of the proposed project. However, construction, in general, can be divided into various phases: ground clearing, site grading, excavation/construction, filling, and finishing. Each of these phases would require varying levels of energy input. Diesel fuel would generally be the main type of energy source required during any construction activities. Prudent energy conservation practices, such as minimization of equipment idling would be incorporated into this project wherever possible during construction activities. Maintenance activities would be anticipated to be consistent with the activities currently occurring within the channel ROW, with maintenance equipment generally being fueled by gasoline. All maintenance activities would be conducted in compliance with the approved Houston/Galveston Clean Air Plan (approved by the EPA on October 15, 2001). New buildings and facilities would incorporate energy-efficient design in compliance with COH LEED requirements. Building heating, ventilation, air condition, domestic hot water systems and equipment would comply with recommendations of the U.S. Department of Energy's Energy Star® Program. Adequate capacity of utilities would be available to provide service to the proposed development. The energy requirements for the proposed construction, operation, and maintenance would not have an adverse impact on the energy requirements of the United States or the greater Houston area. Solar energy, as appropriate, would be used in compliance with LEED standards as required by the COH for new buildings and facilities.

### 4.15.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed, maintained, or operated and energy for these purposes would not be expended. Therefore, energy requirements and conservation potential would not be necessary considerations.

### 4.15.2 Alternative 3A, Alternative 4, and Alternative 6

Energy, in the form of various fossil fuels, would be required during construction, operation, and maintenance of the proposed water supply project. Prudent energy conservation practices, such as minimization of equipment idling would be incorporated into this project wherever possible during construction activities. Maintenance activities would be anticipated to be consistent with the activities currently occurring within the project ROW, with maintenance equipment generally being fueled by gasoline.

#### 4.15.2.1 Construction

At this time, prior to the development of the final detailed design plans and specifications, it would be difficult to determine the specific energy requirements for the construction of the proposed project. However, construction, in general, can be divided into various phases: ground clearing, site grading, excavation/construction, filling, and finishing. Each of these phases would require varying levels of energy input. Diesel fuel would generally be the main type of energy source required during construction activities.

#### 4.15.2.2 Operation and Maintenance

New buildings and facilities would incorporate energy-efficient design in compliance with Houston LEED requirements. Building heating, ventilation, air conditioning, domestic hot water systems and equipment would comply with recommendations of the U.S. Department of Energy's Energy Star® Program. Adequate capacity of utilities would be available to provide service to the proposed development. The energy requirements for the proposed construction, operation, and maintenance would not have an adverse impact on the energy requirements of the United States or the greater Houston area. Solar energy, as appropriate, would be used in compliance with LEED standards as required by the City of Houston for new buildings and facilities.

### 4.15.3 Reduction and Mitigation of Potential Impacts

Prudent energy conservation practices, such as minimization of equipment idling would be incorporated into this project wherever possible during construction activities. All maintenance activities would be conducted in compliance with the approved Houston/Galveston Clean Air Plan (approved by the EPA on October 15, 2001).

## 4.16 Public Benefit

The area directly influenced by Analysis of public benefit includes the Houston metropolitan area represented by the Region H RWP (**Figure 4-1**).

### 4.16.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, the public would not benefit from this long-planned project identified by the State of Texas as critical to providing water to meet projected population growth of Houston. Additionally, they would not benefit from the conversion from groundwater to surface water sources to meet mandated goals developed to control area subsidence.

### 4.16.2 Alternative 3A, Alternative 4, and Alternative 6

The LBITP is the interbasin transfer of raw water from the Trinity River to Lake Houston under an existing water rights diversion permit for treatment at the NEWPP and EWPP owned by the Houston and subsequent distribution to the Houston metropolitan area. All three alternatives provide public benefit to the same degree with respect to water supply. The LBITP is a long-planned project identified by the State of Texas as critical to providing water to meet projected population growth of Houston. The need for the LBITP is to meet projected water requirements as exemplified by Water Supply Contracts held between the Houston and NHCRWA, CHCRWA, WHCRWA, and NFBWA for future water. A secondary objective is to assist with the conversion from groundwater to surface water sources to meet mandated goals developed to control area subsidence. Without the LBITP, the City of Houston would not be able to meet its contracted demand allocations, projected long-term water supply requirements identified by the 2011 Region H RWP and the TWDB 2012 State Water Plan; and would not be able to meet mandated conversion of groundwater to surface water supply sources to control area subsidence by the mandated conversion dates imposed by HGSD and the Fort Bend Subsidence District. The socioeconomic benefit of the proposed LBITP through 2060 to the Houston metropolitan region is estimated on the order of $9 billion dollars.

## 4.17 Relationship between Local Short-Term Uses of Man's Environment and the Maintenance and Enhancement of Long-Term Productivity

The area directly influenced by analysis of the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity not only includes the area of the proposed ROWs including roads, pipeline, canal, pump and discharge stations, the sedimentation basin, the proposed mitigation property, maintenance facility and areas with service utility lines, but also the Houston metropolitan area represented by the Region H RWP boundary and, in addition, the area of Galveston Bay.

Short-term commitments would include labor, capital, and fossil fuels that result directly from construction activities and indirectly from the provision of services to lay down and other areas established to facilitate the construction period. Over the long-term, the proposed LBITP would provide for a reduction in area subsidence and enhancement of water supplies to the Houston metropolitan area. The necessity for infrastructure would exert a long-term impact on the Region H RWP area and the growth of the City of Houston and Texas. Over the long-term, implementation of the LBITP would improve the quality of life for populations of Region H in terms of jobs, housing, income, taxes, and infrastructure growth. The long-term productivity and benefit of the LBITP to the Houston metropolitan region is estimated on the order of $9 billion through 2060.

### 4.17.1 Alternative 3A, Alternative 4, and Alternative 6

The LBITP is the interbasin transfer of raw water from the Trinity River to Lake Houston under an existing water rights diversion permit for treatment at the NEWPP and EWPP owned by the Houston and subsequent distribution to the Houston metropolitan area. All three alternatives would affect on the short-term man's environment and provide on the long-term enhancement of productivity to a similar degree with respect to water supply. Short-term commitments would include labor, capital, and fossil fuels that result directly from construction activities and indirectly from the provision of services to lie down and other areas established to facilitate the construction period. Over the long-term, the proposed LBITP would provide for a reduction in area subsidence and enhancement of water supplies to the Houston metropolitan area. The necessity for infrastructure would exert a long-term impact on the Region H RWP. Over the long-term, implementation of LBITP would improve the quality of life for populations of Region H in terms of jobs, housing, income, taxes, and infrastructure growth. The long-term productivity and benefit of the LBITP to the Houston metropolitan region is estimated on the order of $9 billion through 2060.

## 4.18 Irreversible and Irretrievable Commitments of Resources

The LBITP is the interbasin transfer of raw water from the Trinity River to Lake Houston under an existing water rights diversion permit for treatment at the NEWPP and EWPP owned by the Houston and subsequent distribution to the Houston metropolitan area. All three alternatives would result in irreversible an dirretrievable commitments of resources to a similar degree. The area directly influenced by analysis of irreversible and irretrievable commitments of resources not only includes the area of the proposed project including the proposed 300-foot ROW that would contain roads, the water pipeline easements, canal (Alternative 3A only), pump and discharge stations, sedimentation basin(s), the proposed mitigation property, maintenance facility and areas with service utility lines.

Irreversible commitments are those that cannot be reversed, except perhaps in the extreme long-term. The classic instance is when a species becomes extinct; this is an irreversible loss. Irretrievable commitments are those that are lost for a period of time. If an interstate is constructed through a forest, the timber productivity along the proposed project ROW is lost as long as the highway is operational. The construction of the LBITP signals an irretrievable loss of private land in exchange for the public benefit gained by the project implementation as the City of Houston exercises their rights to the water supplied from the lower Trinity River watershed.

Construction and long-term maintenance of the proposed public water supply project would require the commitment of various resources. These resources could include the commitment of labor, capital, energy, biological resources, building materials, fiscal and land resources. Short-term commitments of labor, capital, and fossil fuels would result directly from construction of the proposed improvements and indirectly from the provisions of services to the various sites during construction. Long-term commitments of resources would result directly from maintenance of the project and indirectly from the provisions of water, sewage, electricity, gas, and solid waste services for proposed facilities. Additionally, substantial amounts of labor and natural resources would be required for the fabrication and preparation of the construction materials. Although these materials are generally irretrievable, they are not in short supply, and their use would not have an adverse effect on continued availability of these resources. Any construction would also require a substantial expenditure of local and state funds, which are not retrievable. All of these losses would be considered irretrievable.

Duration of the commitment of land resources would depend on the ultimate reuse and life of the facilities and property. Since the proposed preferred use of the land is for public water supply for the Houston metropolitan area, the commitment of land resources is long-term, and represents an irretrievable loss.

The commitment of these resources is based on the concept that residents in Region H would benefit by the provision of long-term water supplies. These benefits are anticipated to outweigh the commitment of resources.

### 4.18.1 No Action

Under the No Action Alternative, the proposed LBITP would not be constructed or operated. As a result, no irreversible and irretrievable commitments of resources would be required as a direct result of No Action. However, indirect effects would occur as the irreversible and irritrevable loss of water resources from Region H groundwater resources and additional sources of surface water supplies are developed to meet demand.

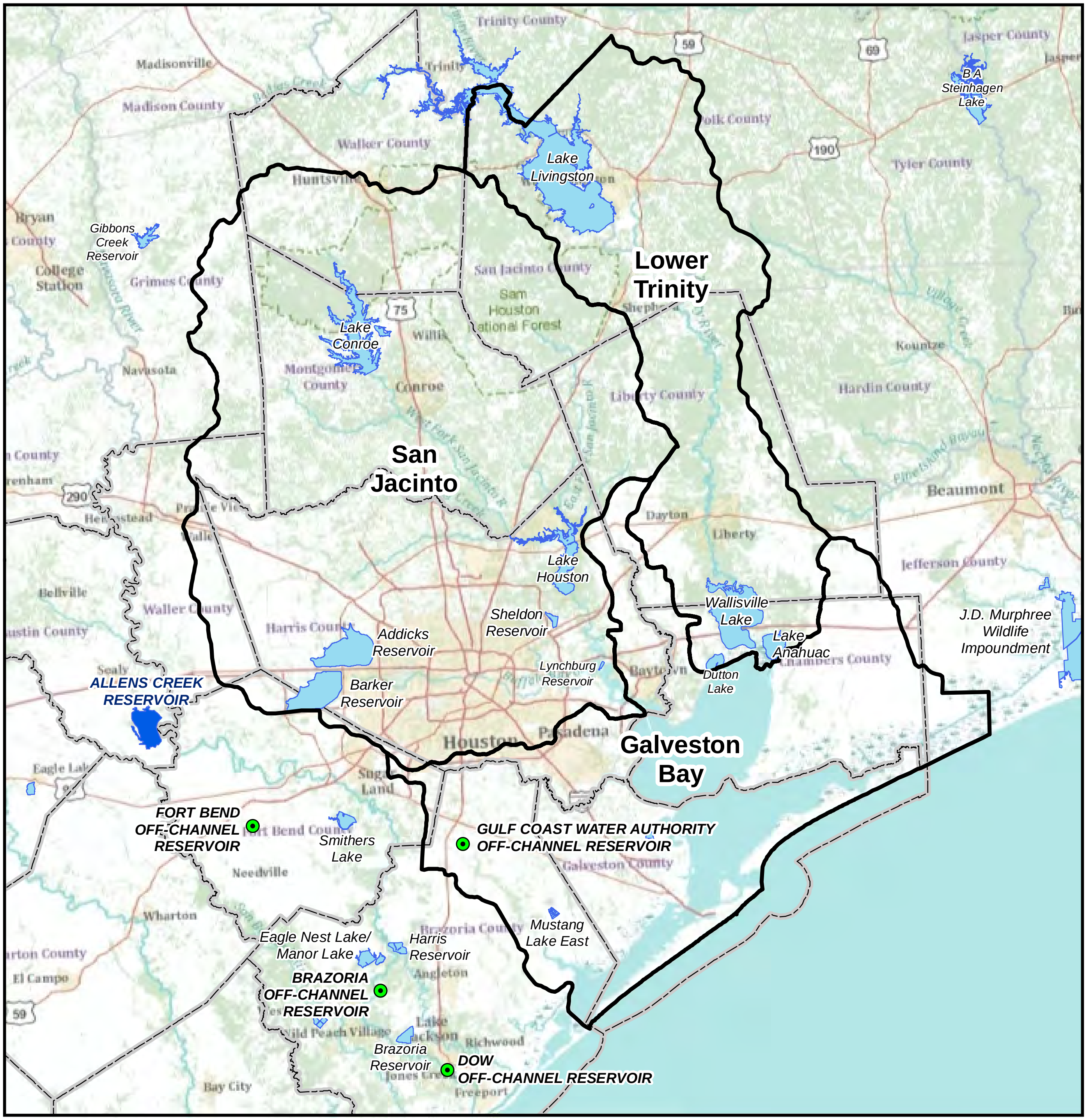
### 4.18.2 Alternative 3A, Alternative 4, and Alternative 6

Irreversible commitments are those that cannot be reversed, except perhaps in the extreme long-term. The classic instance is when a species becomes extinct; this is an irreversible loss. Irretrievable commitments are those that are lost for a period of time. Such as, if an interstate is constructed through a forest, the timber productivity along the road ROW is lost for as long as the highway remains. The construction of Alternative 3A signals an irretrievable loss in exchange for the public benefit gained by the project implementation.

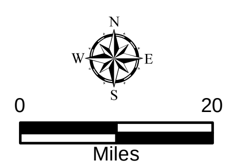
Construction and long-term maintenance of the proposed public water supply project would require the commitment of various resources. These resources could include the commitment of labor, capital, energy, biological resources, building materials, fiscal and land resources. Short-term commitments of labor, capital, and fossil fuels would result directly from construction of the proposed improvements and indirectly from the provisions of services to the various sites during construction. Long-term commitments of resources would result directly from maintenance of the project and indirectly from the provisions of water, sewage, electricity, gas, and solid waste services for proposed facilities. Additionally, substantial amounts of labor and natural resources would be required for the fabrication and preparation of the construction materials. Although these materials are generally irretrievable, they are not in short supply, and their use would not have an adverse effect on continued availability of these resources. Construction would also require a substantial expenditure of local and state funds, which are not retrievable. All of these losses would be considered irretrievable.

Duration of the commitment of land resources would depend on the ultimate reuse and life of the facilities and property. Since the proposed preferred use of the land is for public water supply for the Houston metropolitan area, the commitment of land resources is long-term, and represents an irretrievable loss.

The commitment of these resources is based on the concept that residents in Region H would benefit by the provision of long-term water supplies. These benefits are anticipated to outweigh the commitment of resources.




Base from ESRI Online accessed December 2011;
Existing and recommended reservoirs from TWDB.




## Legend

- Recommended Off Channel Reservoir (general location shown)
- Watershed Boundary
- Existing Reservoirs
- Recommended Reservoir
- County Boundary

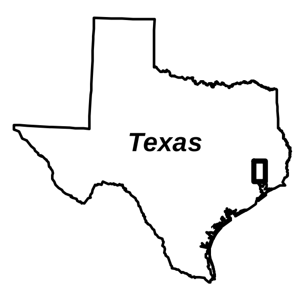
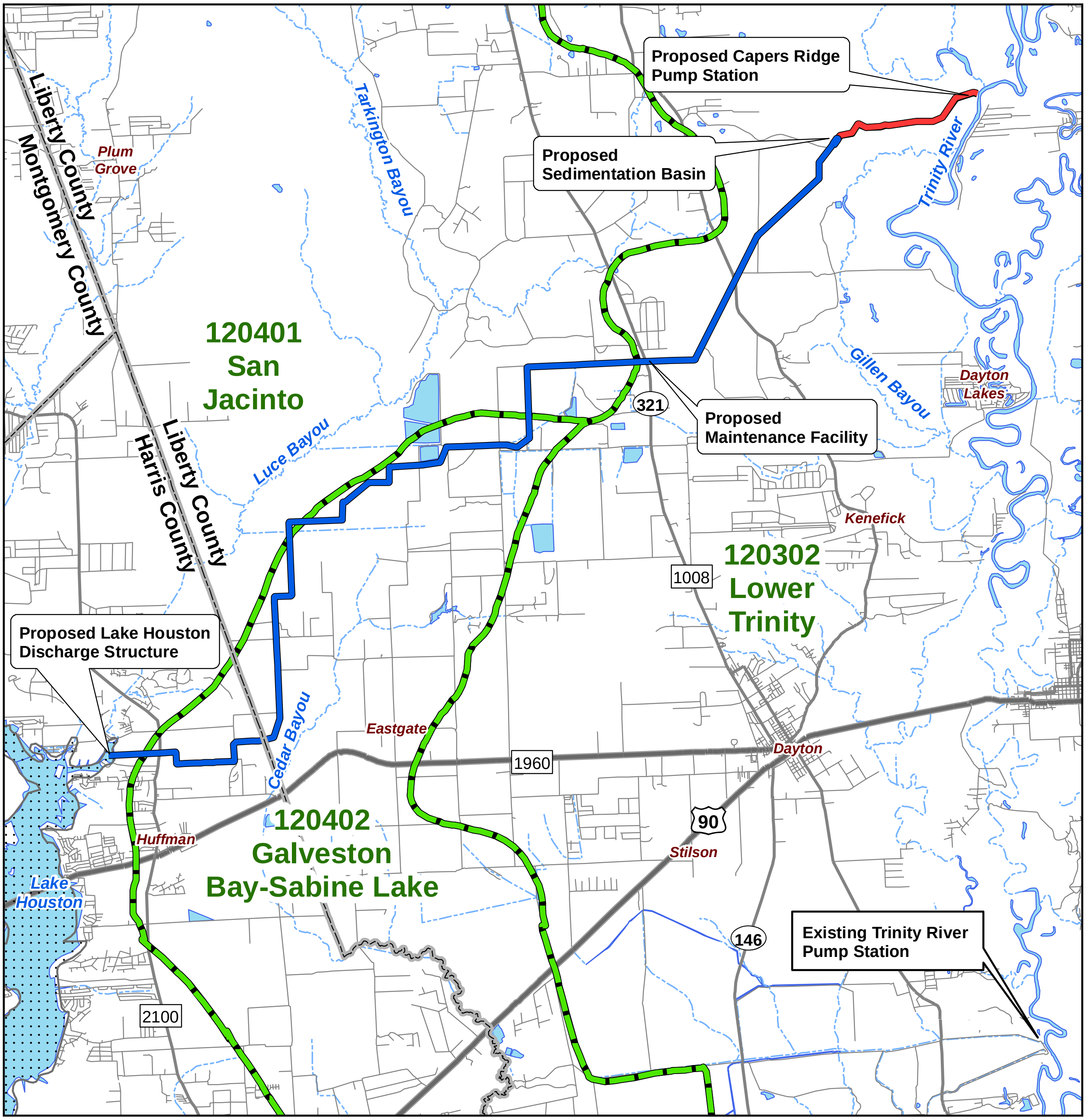


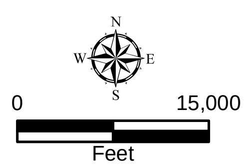

**Figure 4-1 : Existing and Recommended Water Supply Reservoirs as Shown in the 2012 State Water Plan**

**Luce Bayou Interbasin Transfer Project**

\\Ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-1_Water Supply Map.mxd




Source:
Flowline, waterbody and watershed boundaries from National Hydrography Dataset (NHD), USGS
ftp://nhdftp.usgs.gov/SubRegions/
Basemap Source: ESRI 2008 StreetMap data.




**Legend**

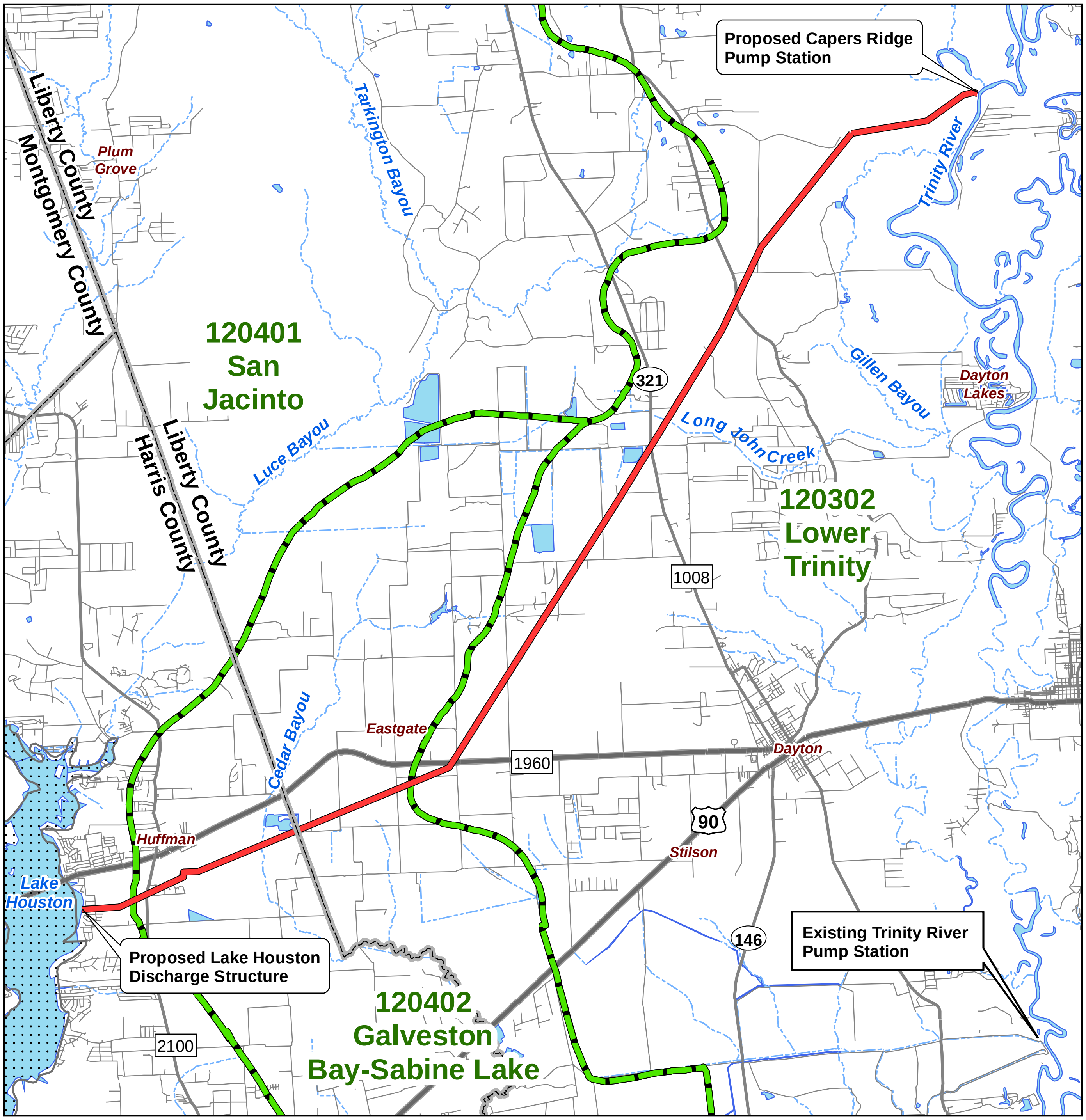
- Alternative 3A Canal
- Alternative 3A Pipeline
- Highway
- Major Road
- Local Road
- Streams, Rivers
- Lakes, Reservoirs
- USGS Hydrologic Unit Code (HUC)
- Existing Reservoir
- County Boundary

Location Map

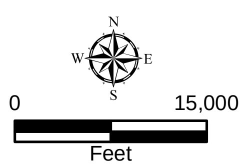
**Figure 4-4: National Hydrography Dataset (NHD) Watershed Boundary Map**

**Luce Bayou Interbasin Transfer Project**

Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-4_NHD Watershed Boundary Map.mxd




Source:
Flowline, waterbody and watershed boundaries from
National Hydrography Dataset (NHD), USGS
ftp://nhdftp.usgs.gov/SubRegions/
Basemap Source: ESRI 2008 StreetMap data.



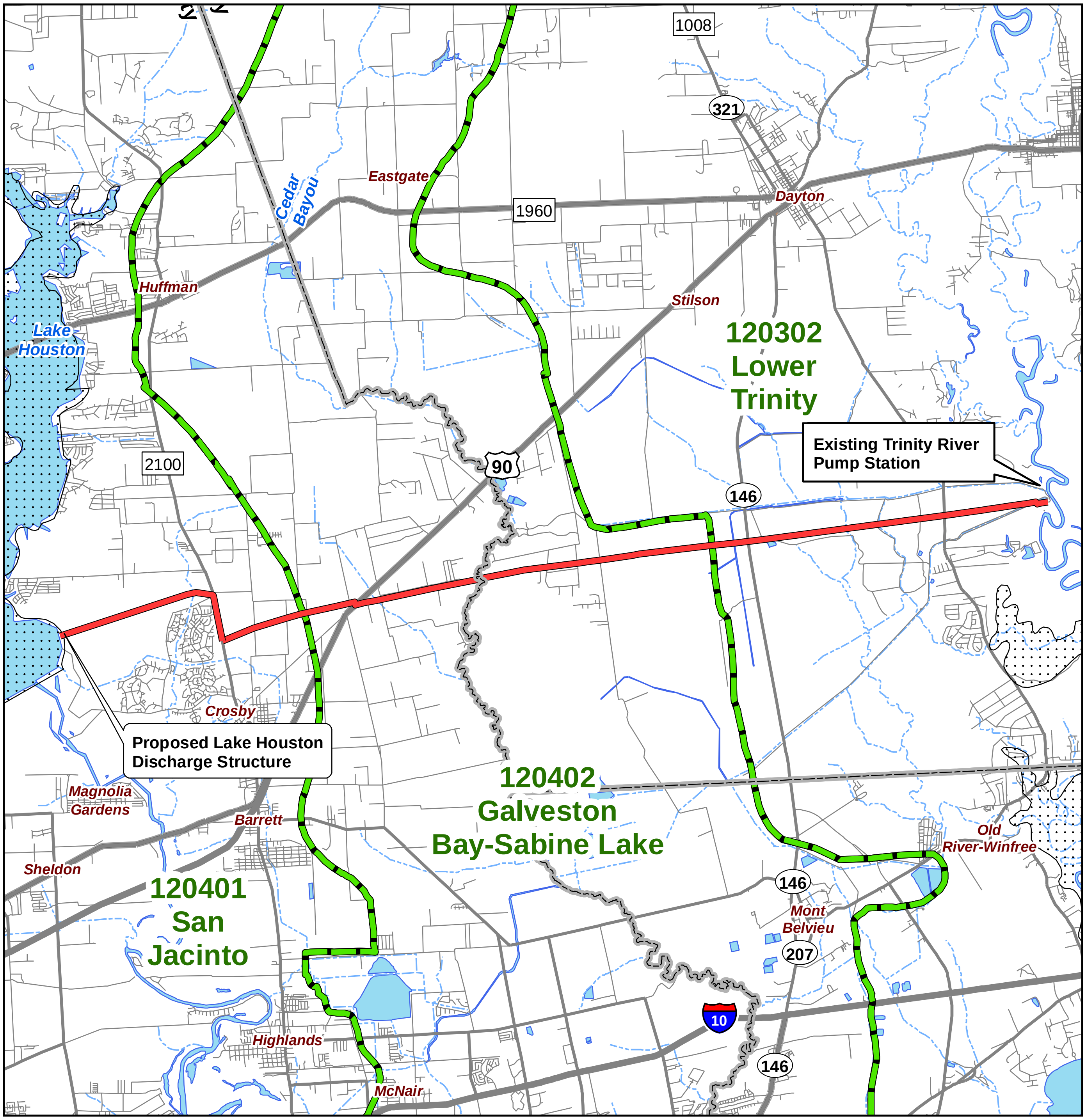

**Legend**

Alternative 4 Pipeline
Highway
Major Road
Local Road
Streams, Rivers
Lakes, Reservoirs
USGS Hydrologic Unit Code (HUC)
Existing Reservoir
County Boundary

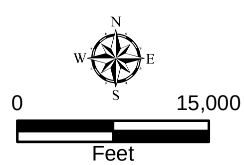

**Figure 4-5: National Hydrography Dataset (NHD) Watershed Boundary Map**

**Luce Bayou Interbasin Transfer Project**

Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-5_NHD Watershed Boundary Map.mxd




Source:
Flowline, waterbody and watershed boundaries from National Hydrography Dataset (NHD), USGS ftp://nhdftp.usgs.gov/SubRegions/
Basemap Source: ESRI 2008 StreetMap data.




**Legend**

- Alternative 6 Pipeline
- Highway
- Major Road
- Local Road
- Streams, Rivers
- Lakes, Reservoirs
- USGS Hydrologic Unit Code (HUC)
- Existing Reservoir
- County Boundary


Location Map

**Figure 4-6: National Hydrography Dataset (NHD) Watershed Boundary Map**

**Luce Bayou Interbasin Transfer Project**

Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-6_NHD Watershed Boundary Map.mxd

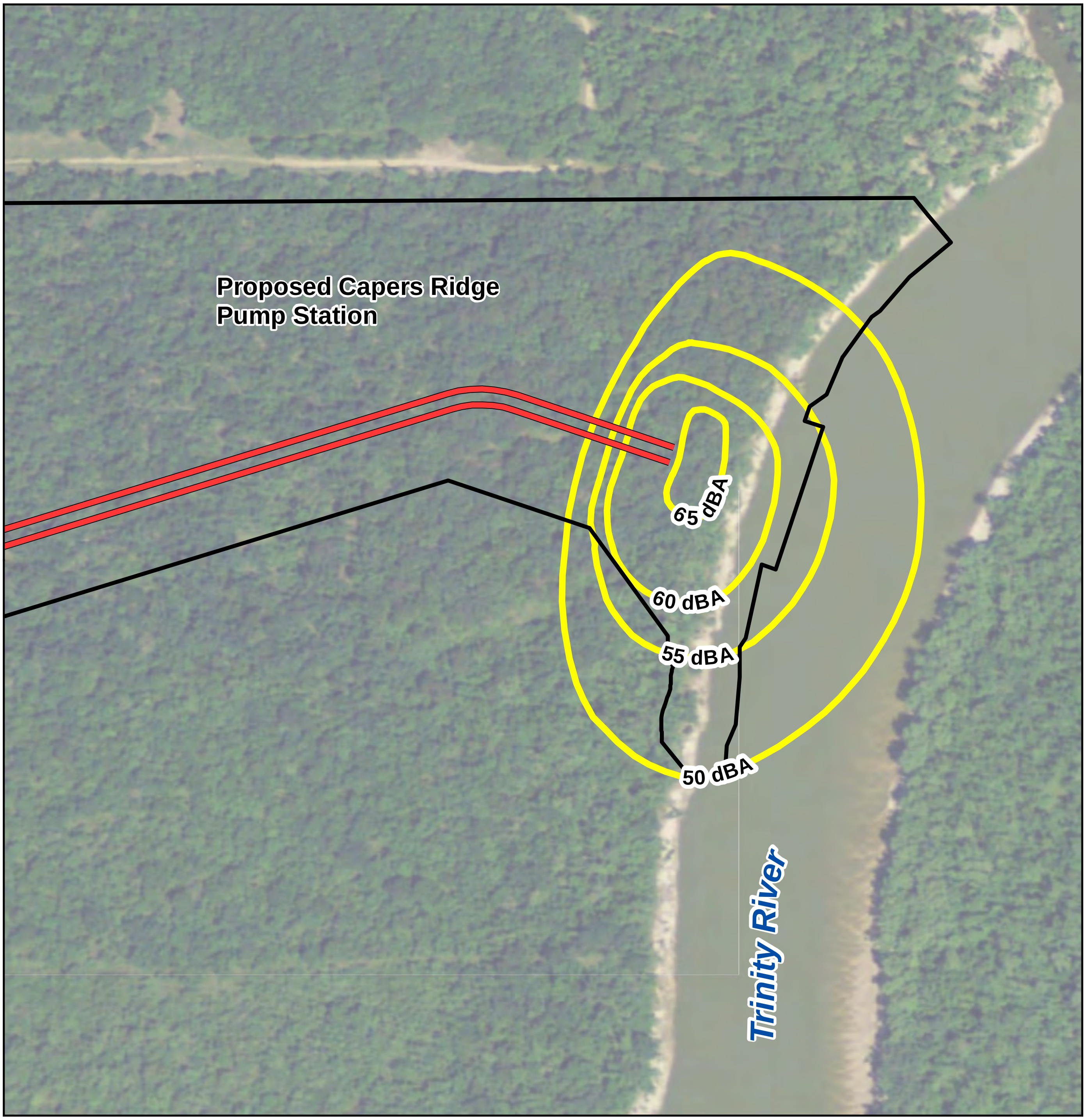
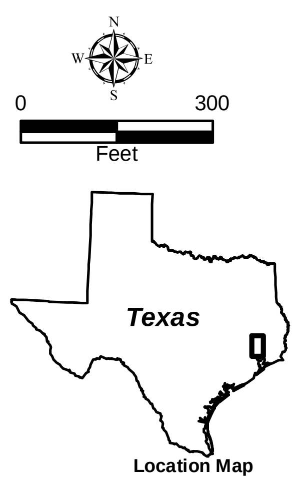



Image Source: Natural Color USDA NAIP Texas 2010




## Legend

Alternative 3A Pipeline

Noise Contours (dBA)

Proposed ROW

**Figure 4-13: Noise Contour Map CRPS Alternative 3A**

**Luce Bayou Interbasin Transfer Project**

Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-13_Noise Contour Map CRPS Alternative 3A.mxd

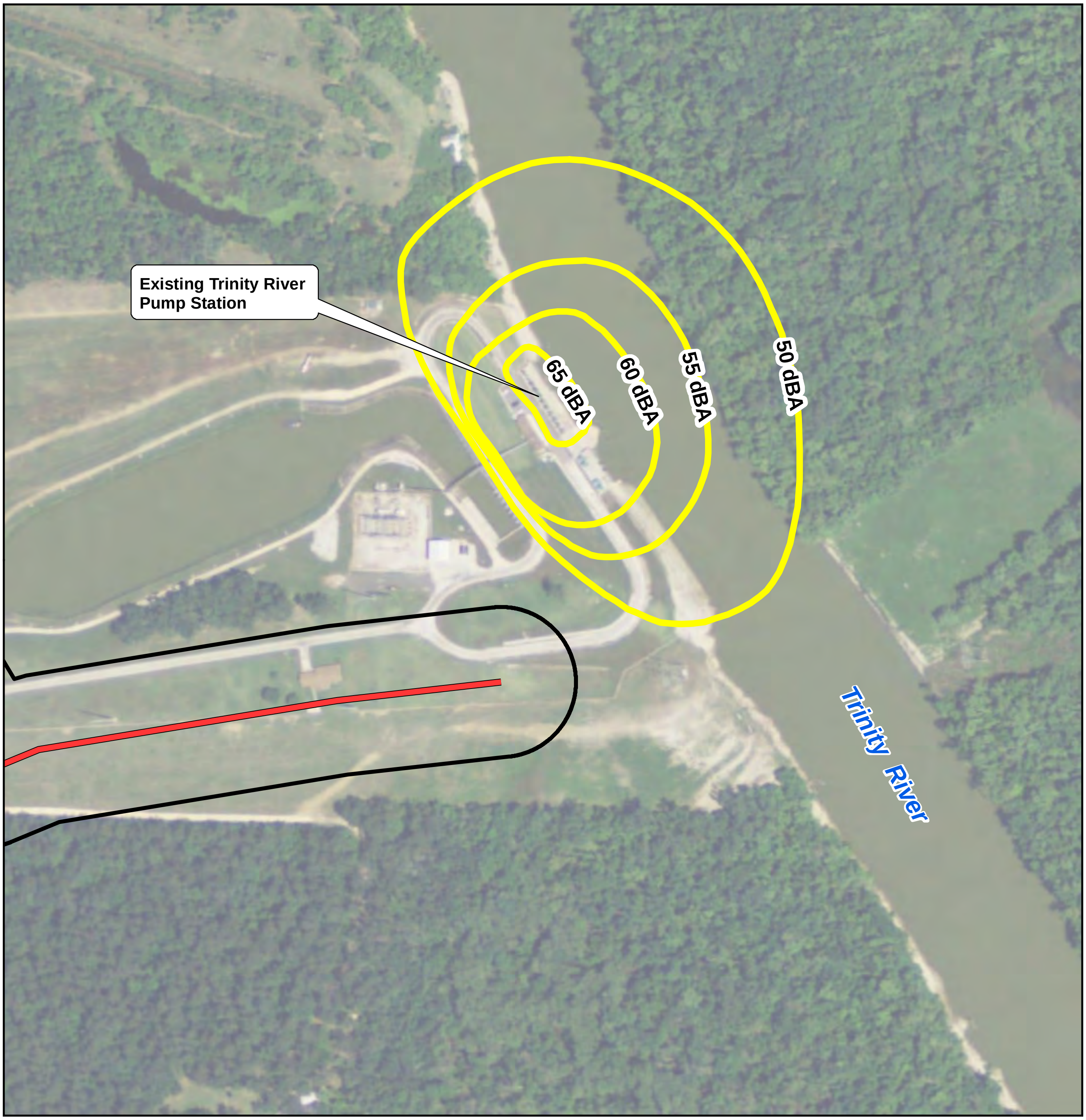
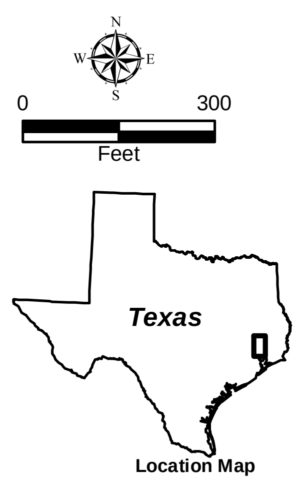



Image Source: Natural Color USDA NAIP Texas 2010



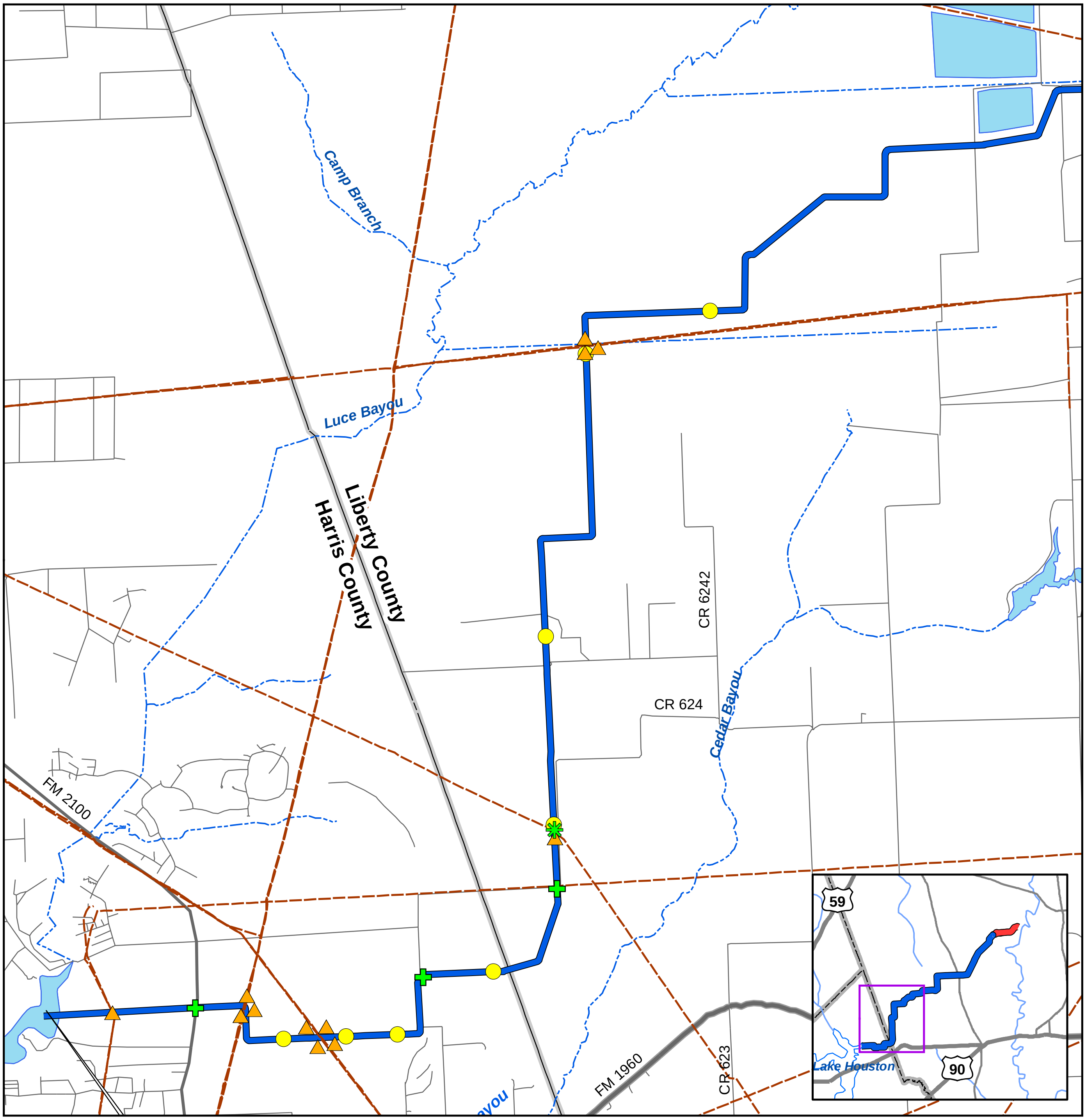

## Legend

- Alternative 6 Pipeline
- Noise Contours (dBA)
- Proposed ROW

**Figure 4-14: Noise Contour Map TRPS Alternative 6**

**Luce Bayou Interbasin Transfer Project**

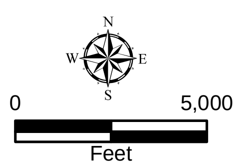
Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-14_Noise Contour Map TRPS Alternative 6.mxd




Basemap Source: ESRI 2008 StreetMap data.
Pipelines Source - Railroad Commission of Texas

## Legend

- Alternative 3A Canal
- Alternative 3A Pipeline
- Oil & Gas Pipelines
- Electrical Crossing
- PipelineCrossings
- Siphon Crossings
- Flow Control Structures
- Lakes, Reservoirs
- County Boundary



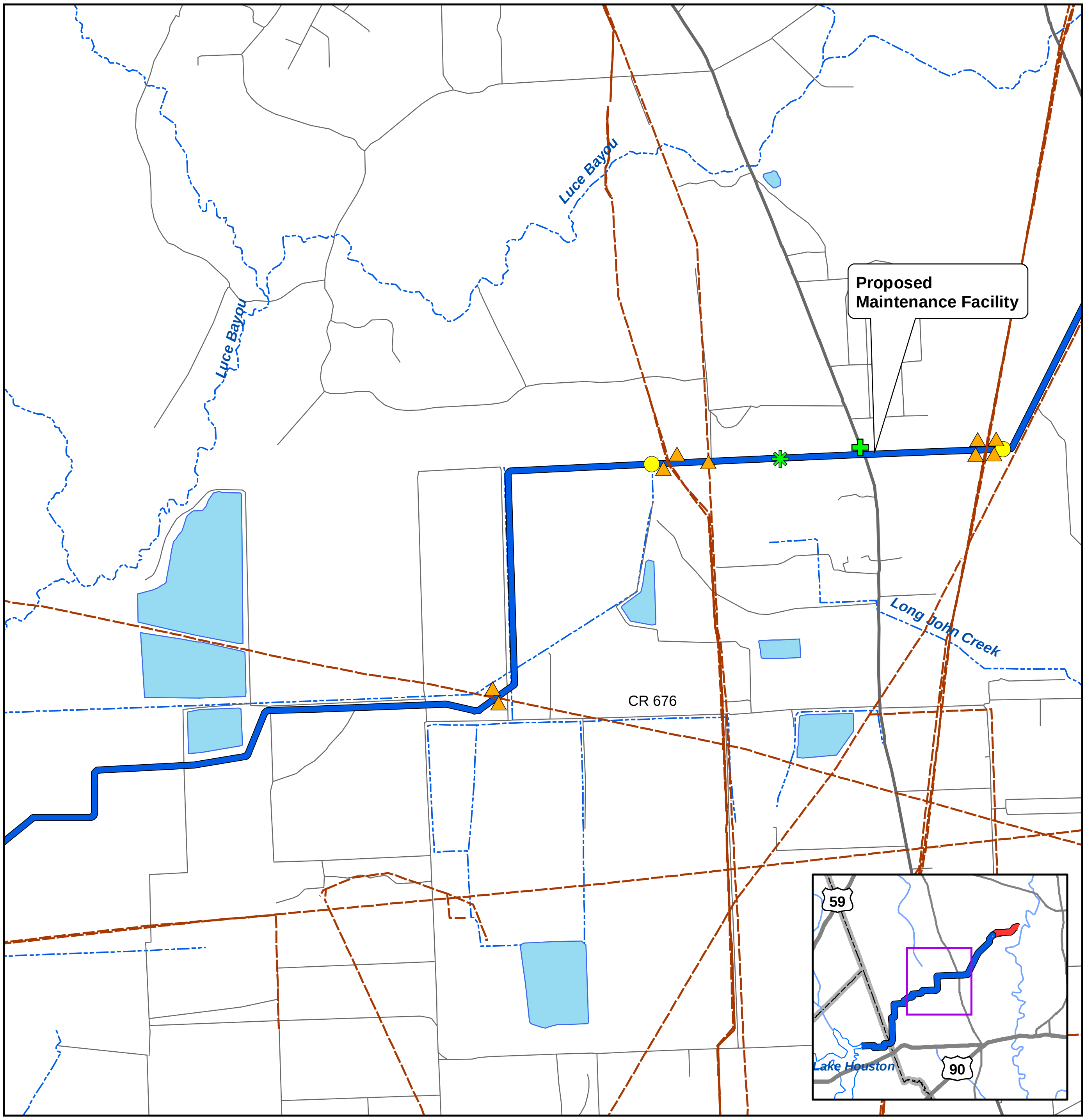


Location Map

**Figure 4-22a: Identified Crossings**

**Luce Bayou Interbasin Transfer Project**

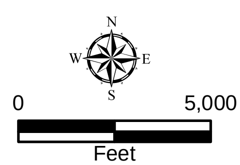
Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-22_Identified Crossings.mxd




Basemap Source: ESRI 2008 StreetMap data.
Pipelines Source - Railroad Commission of Texas

## Legend

- Alternative 3A Canal
- Alternative 3A Pipeline
- Oil & Gas Pipelines
- Electrical Crossing
- PipelineCrossings
- Siphon Crossings
- Flow Control Structures
- Lakes, Reservoirs
- County Boundary



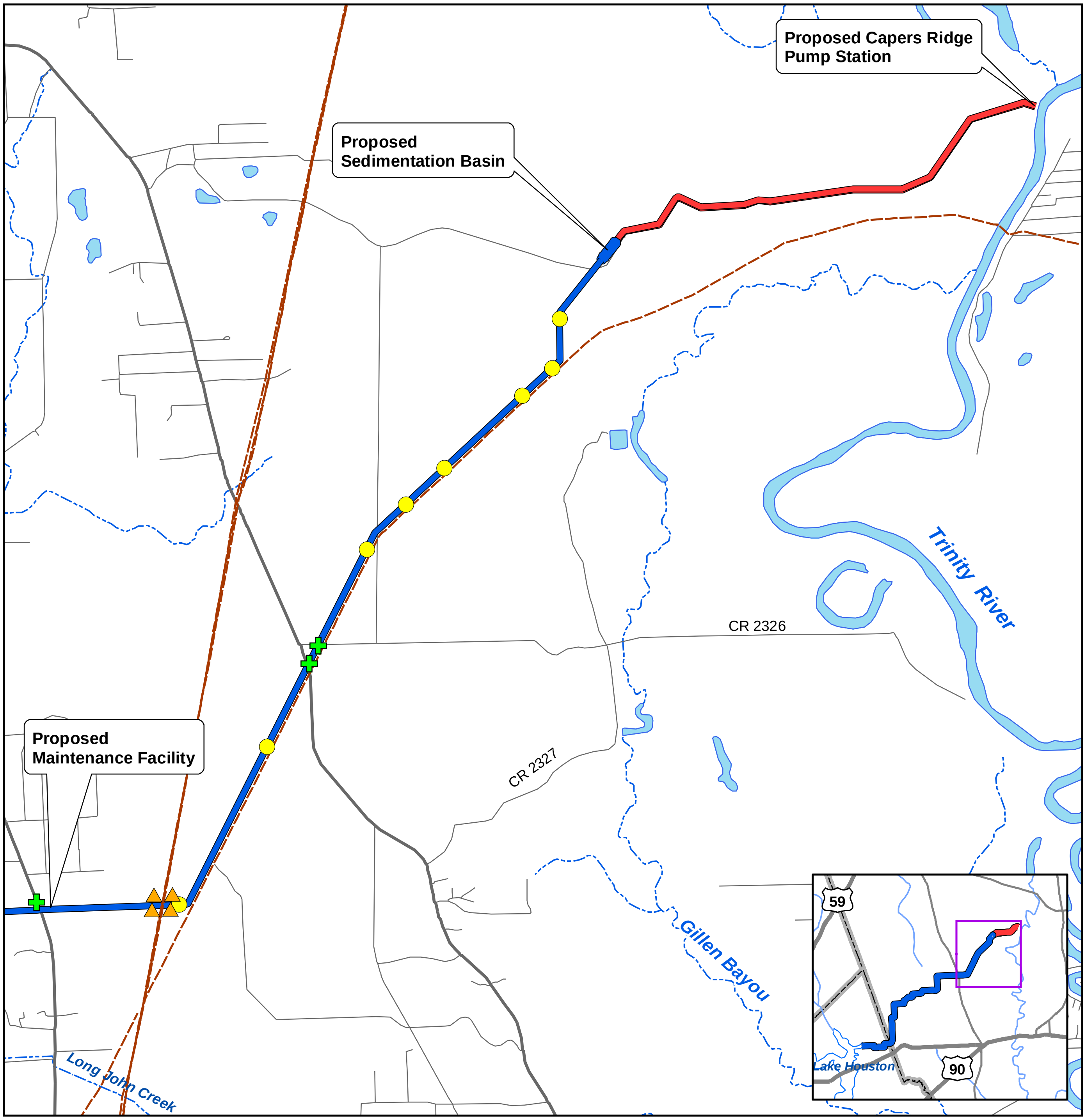


Location Map

**Figure 4-22b: Identified Crossings**

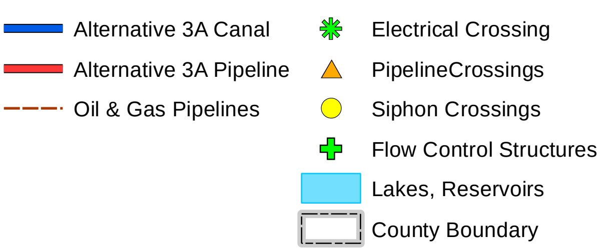
**Luce Bayou Interbasin Transfer Project**

Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-22_Identified Crossings.mxd




Basemap Source: ESRI 2008 StreetMap data.
Pipelines Source - Railroad Commission of Texas

## Legend



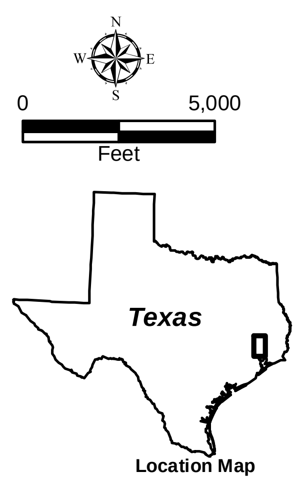
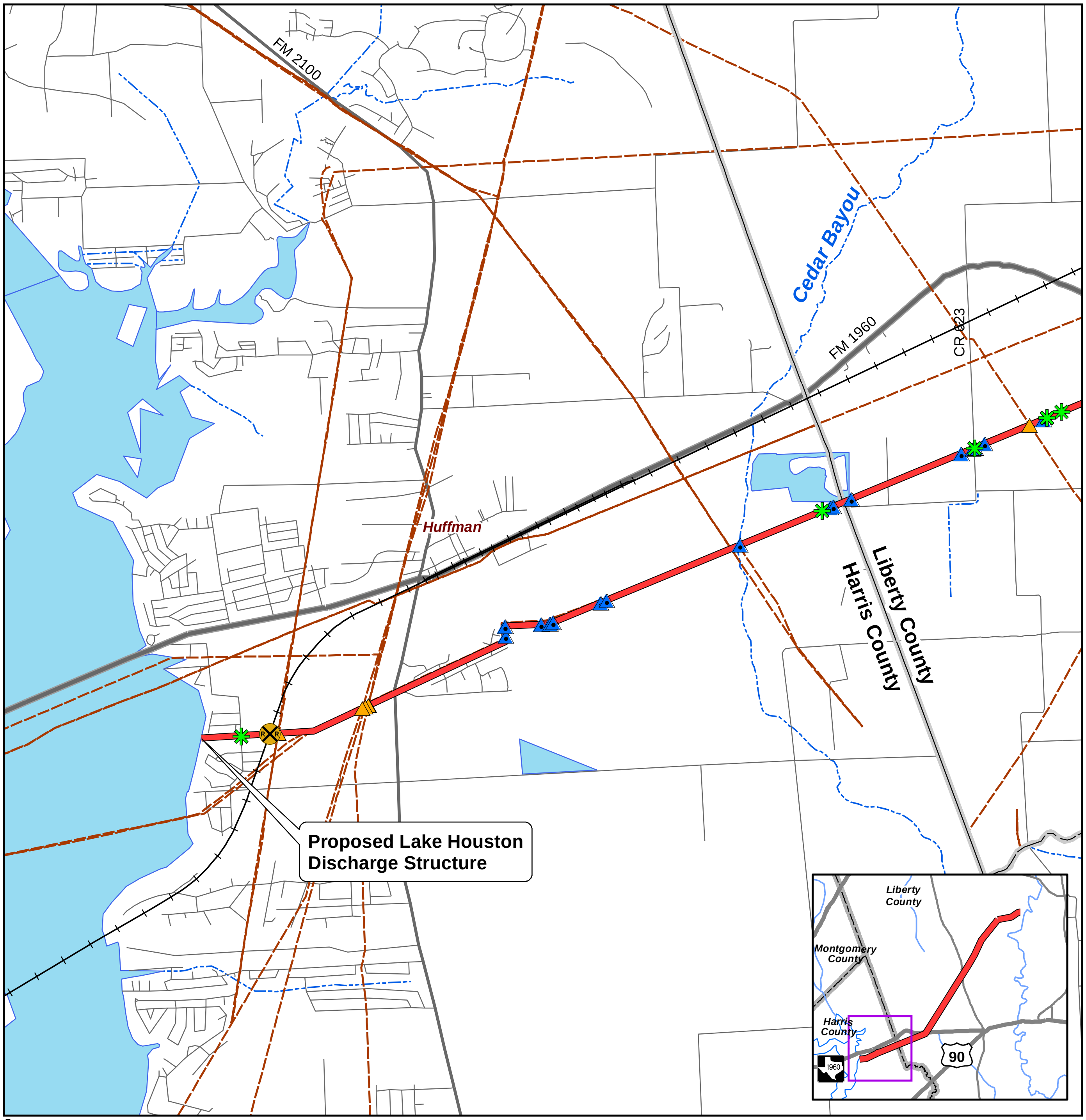



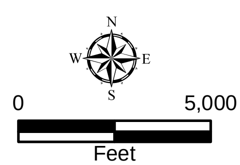

**Figure 4-22c: Identified Crossings**

**Luce Bayou Interbasin Transfer Project**

Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-22_Identified Crossings.mxd




Sources:
Basemap: ESRI 2008 StreetMap data.
Pipelines: Railroad Commission of Texas
Railroads: TNRIS
Stream Crossings: USGS National Hydrography Dataset Flowlines




## Legend

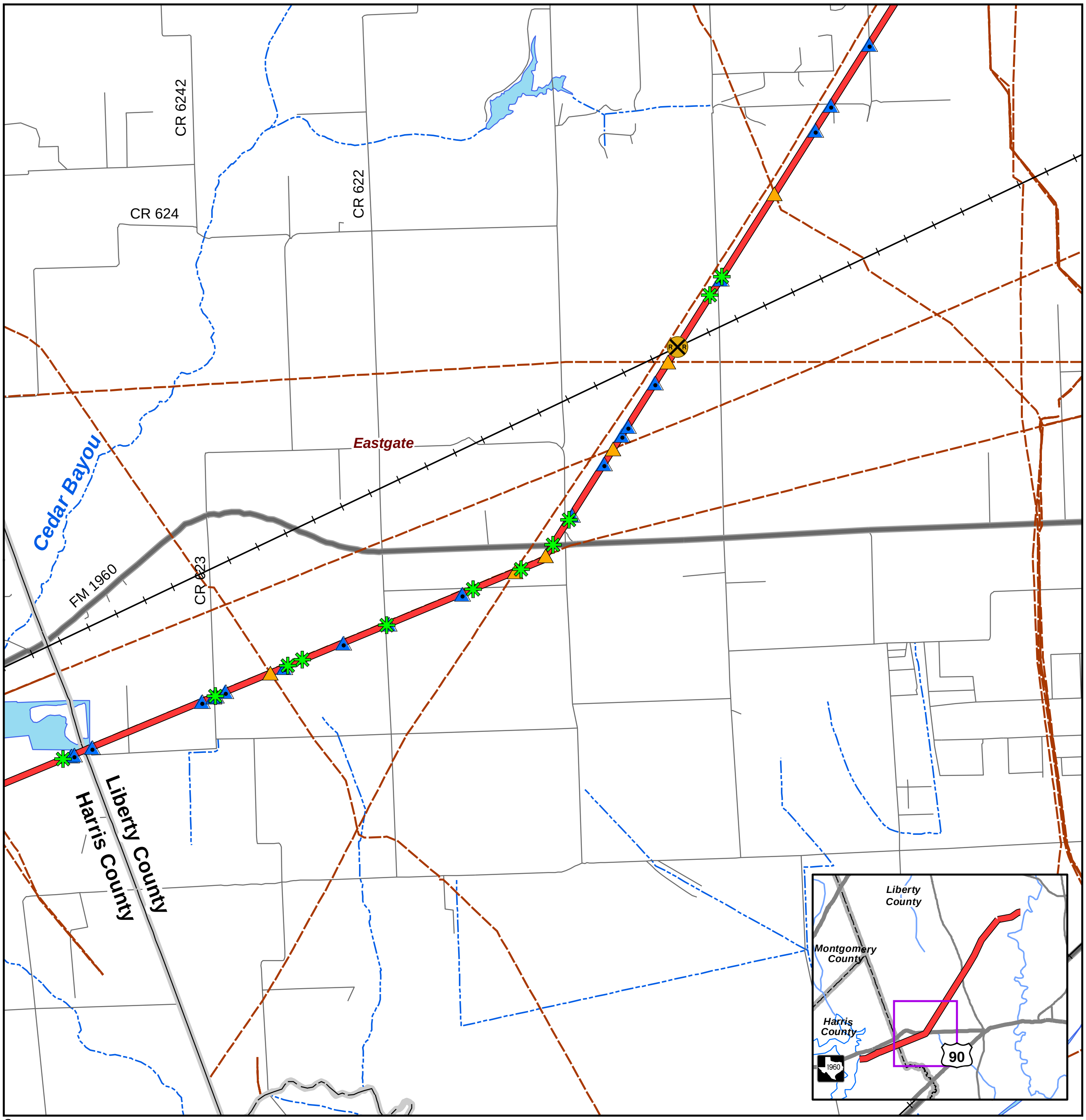
- Alternative 4 Pipeline
- Pipelines
- Railroad
- Electrical Crossings
- Pipeline Crossings
- Stream Crossings
- Railroad Crossings
- Streams, Rivers
- Lakes, Reservoirs
- County Boundary


Location Map

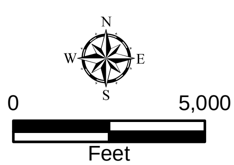
**Figure 4-23a: Identified Crossings**

**Luce Bayou Interbasin Transfer Project**

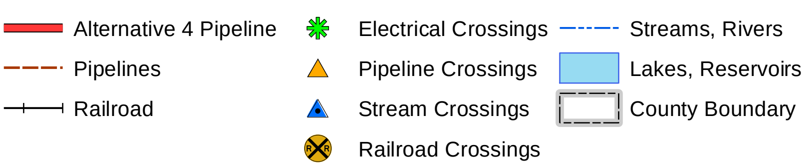
Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-23_Identified Crossings.mxd




Sources:
Basemap: ESRI 2008 StreetMap data.
Pipelines: Railroad Commission of Texas
Railroads: TNRIS
Stream Crossings: USGS National Hydrography Dataset Flowlines




## Legend





Location Map

**Figure 4-23b: Identified Crossings**

**Luce Bayou Interbasin Transfer Project**

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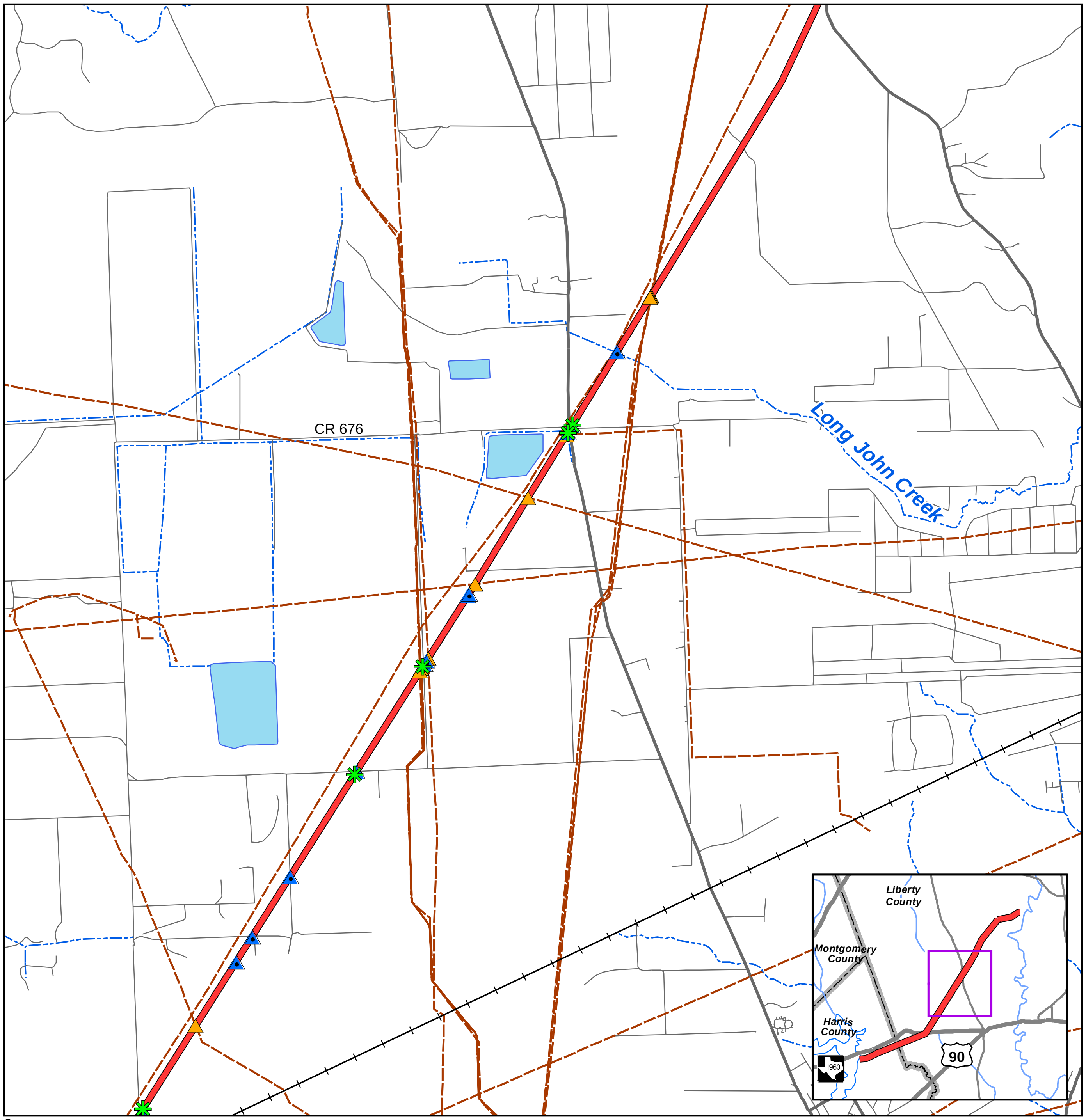
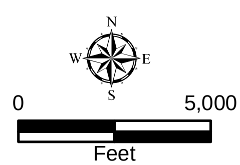



Sources:
Basemap: ESRI 2008 StreetMap data.
Pipelines: Railroad Commission of Texas
Railroads: TNRIS
Stream Crossings: USGS National Hydrography Dataset Flowlines




## Legend

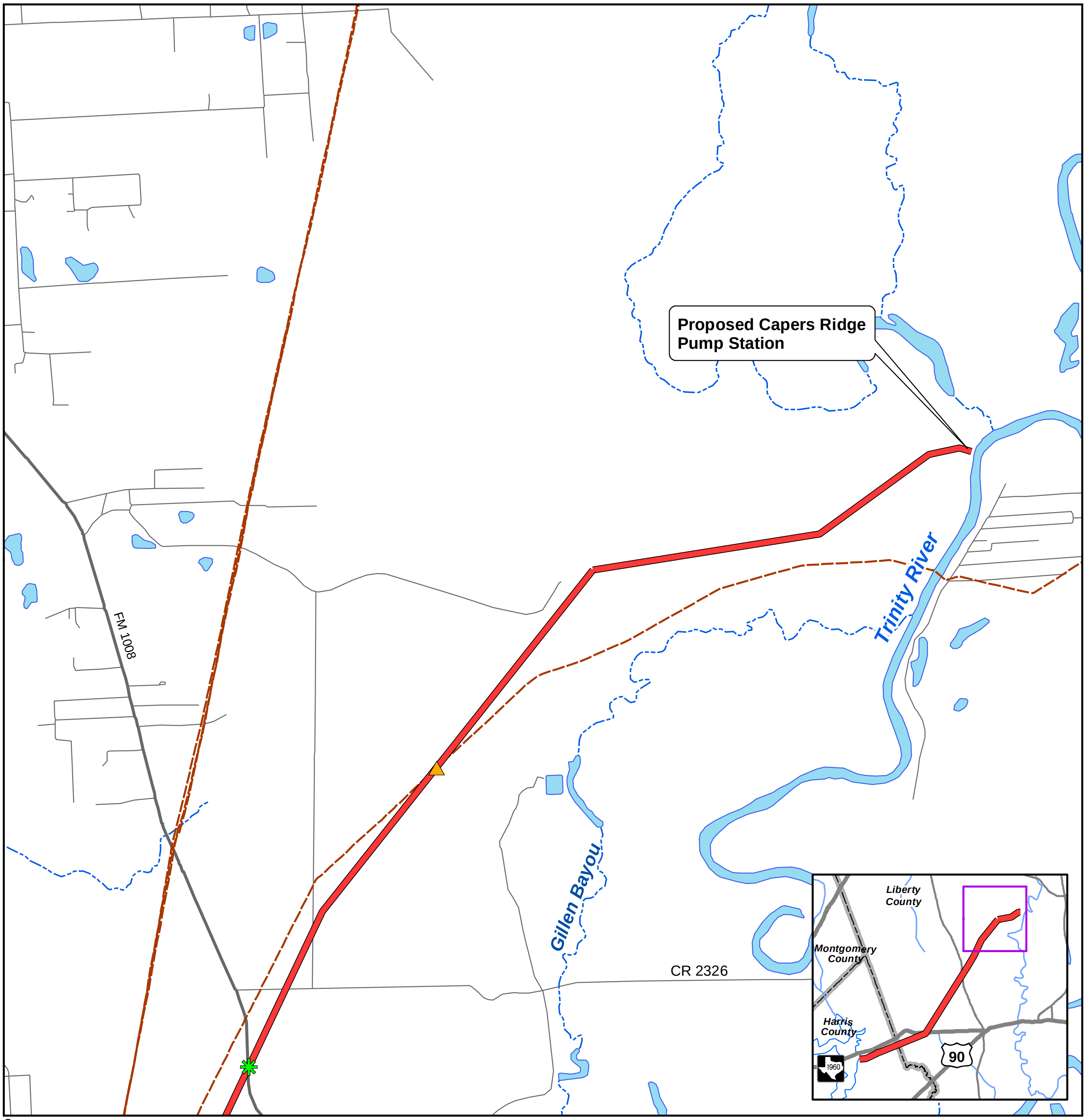
Alternative 4 Pipeline
Pipelines
Railroad
Electrical Crossings
Pipeline Crossings
Stream Crossings
Railroad Crossings
Streams, Rivers
Lakes, Reservoirs
County Boundary


**Figure 4-23c: Identified Crossings**

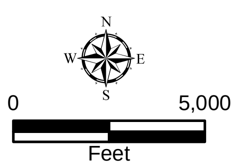
**Luce Bayou Interbasin Transfer Project**

**Location Map**

Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-23_Identified Crossings.mxd




Sources:
Basemap: ESRI 2008 StreetMap data.
Pipelines: Railroad Commission of Texas
Railroads: TNRIS
Stream Crossings: USGS National Hydrography Dataset Flowlines




## Legend

- Alternative 4 Pipeline
- Pipelines
- Railroad
- Electrical Crossings
- Pipeline Crossings
- Stream Crossings
- Railroad Crossings
- Streams, Rivers
- Lakes, Reservoirs
- County Boundary


Location Map

**Figure 4-23d: Identified Crossings**

**Luce Bayou Interbasin Transfer Project**

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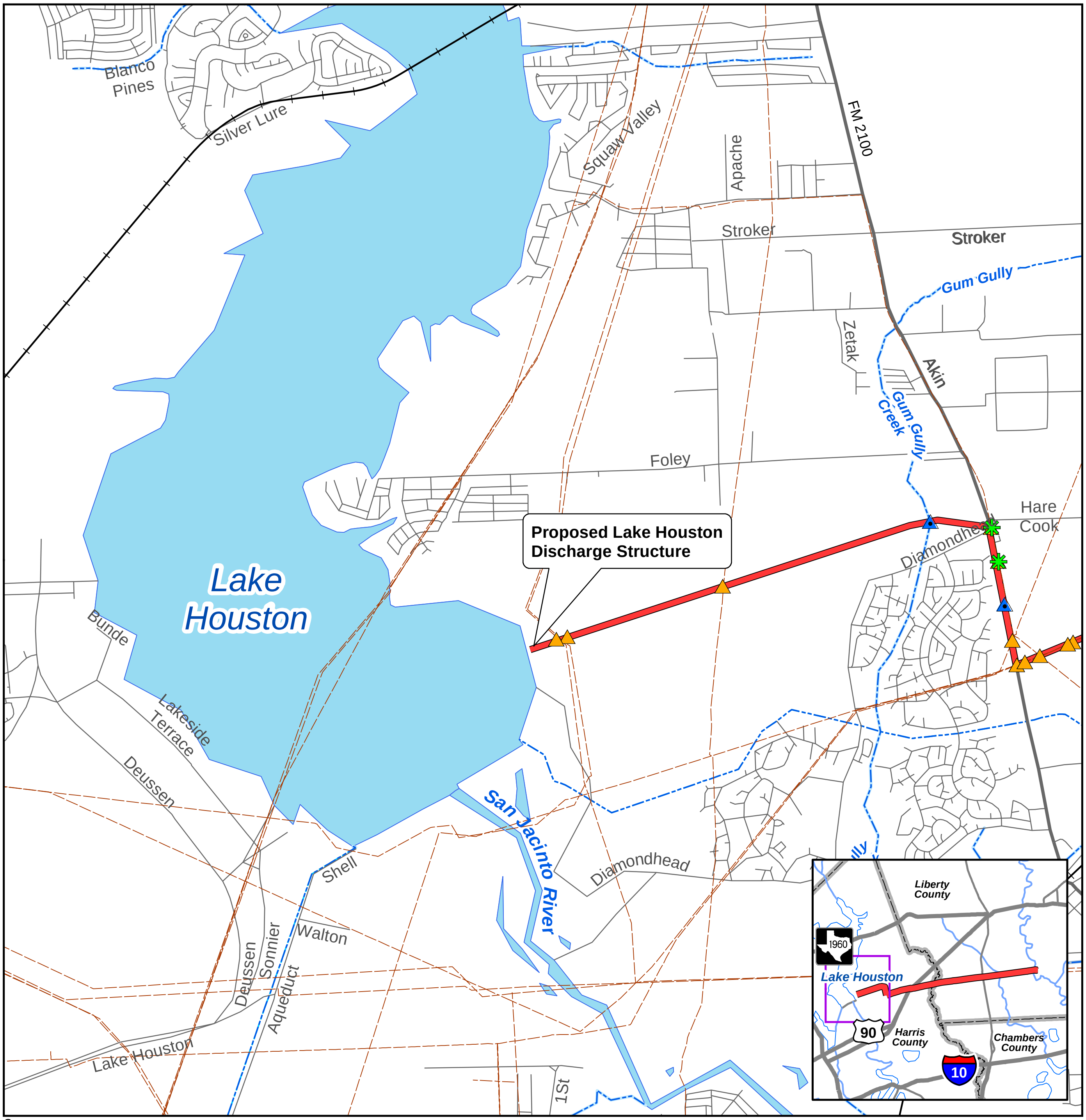


Sources:
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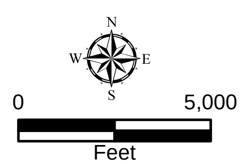
Pipelines: Railroad Commission of Texas
Railroads: TNRIS
Stream Crossings: USGS National Hydrography Dataset Flowlines




## Legend

- Alternative 6 Pipeline
- Pipelines
- Railroad
- Electrical Crossing
- Pipeline Crossings
- Stream Crossings
- Railroad Crossings
- Streams, Rivers
- Lakes, Reservoirs
- County Boundary

Location Map

**Figure 4-24a: Identified Crossings**

**Luce Bayou Interbasin Transfer Project**

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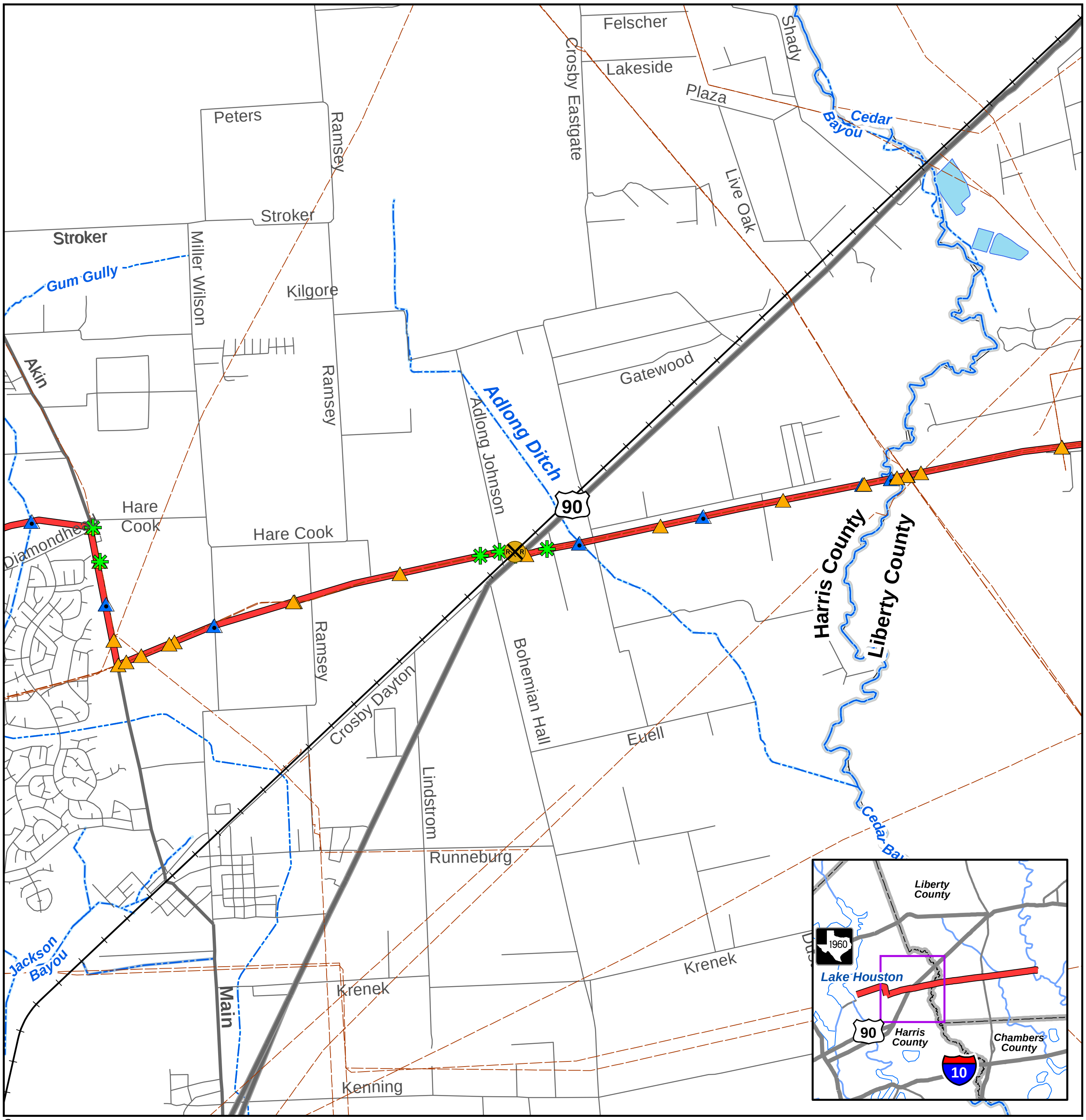


Sources:
Basemap: ESRI 2008 StreetMap data.
Pipelines: Railroad Commission of Texas
Railroads: TNRIS
Stream Crossings: USGS National Hydrography Dataset Flowlines



## Legend

| | | |
|---|---|---|
| Alternative 6 Pipeline | Electrical Crossing | Streams, Rivers |
| Pipelines | Pipeline Crossings | Lakes, Reservoirs |
| Railroad | Stream Crossings | County Boundary |
| | Railroad Crossings | |


Location Map

**Figure 4-24b: Identified Crossings**

**Luce Bayou Interbasin Transfer Project**

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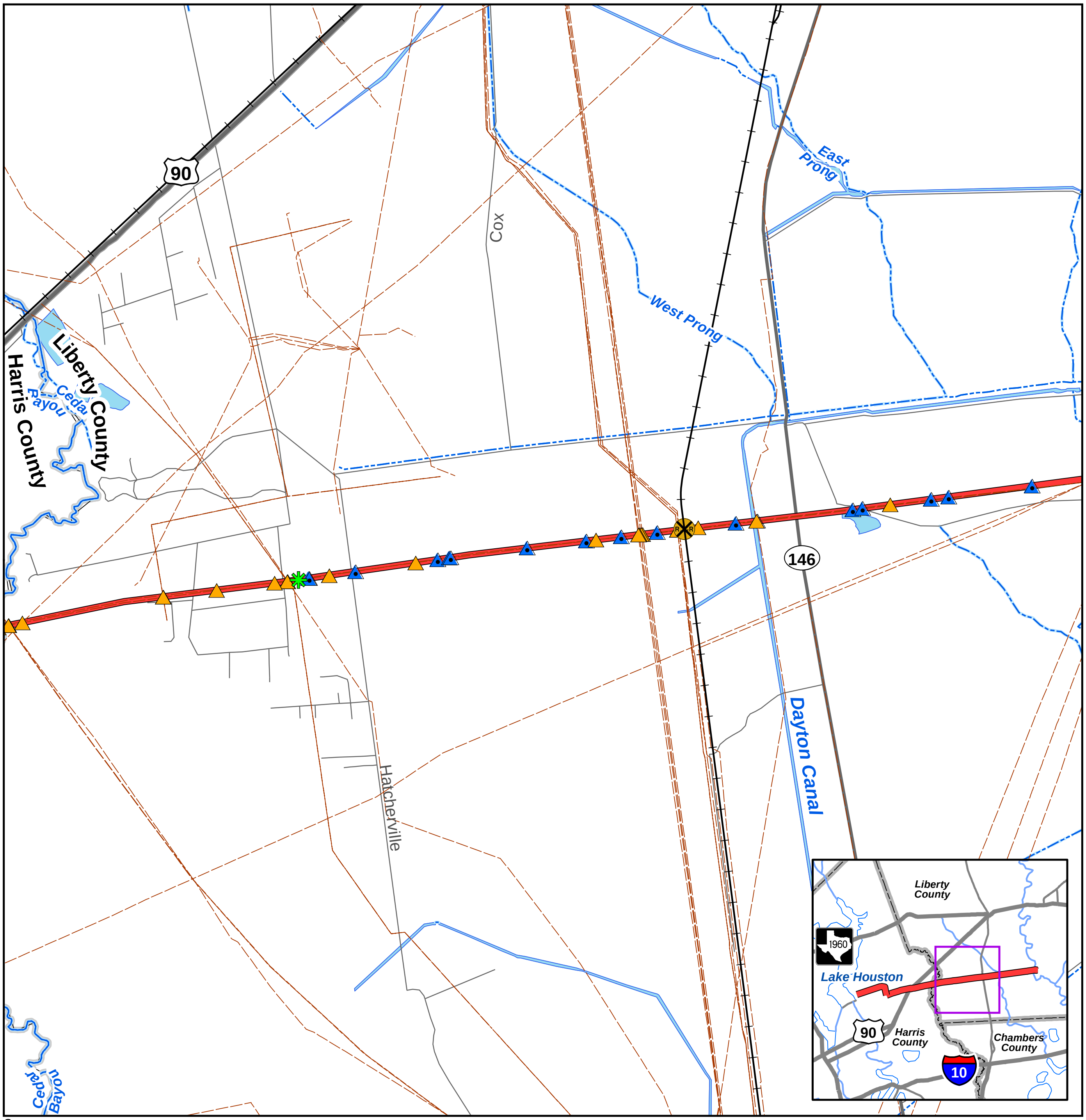
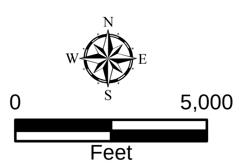



Sources:
Basemap: ESRI 2008 StreetMap data.
Pipelines: Railroad Commission of Texas
Railroads: TNRIS
Stream Crossings: USGS National Hydrography Dataset Flowlines




## Legend

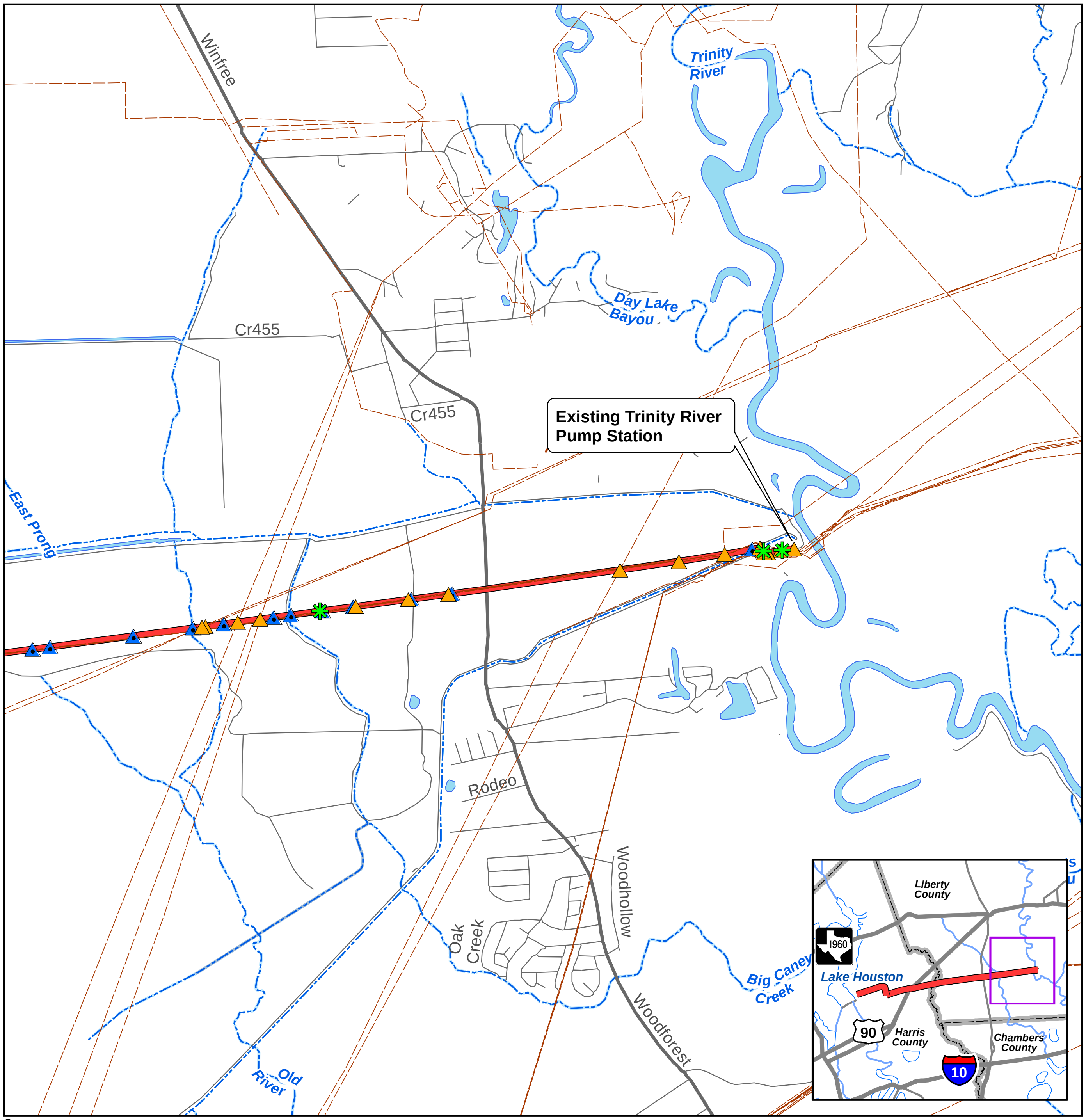
- Alternative 6 Pipeline
- Pipelines
- Railroad
- Electrical Crossing
- Pipeline Crossings
- Stream Crossings
- Railroad Crossings
- Streams, Rivers
- Lakes, Reservoirs
- County Boundary


Location Map

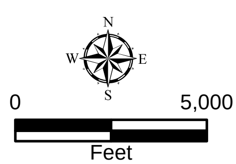
**Figure 4-24c: Identified Crossings**

**Luce Bayou Interbasin Transfer Project**

Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-24_Identified Crossings.mxd




Sources:
Basemap: ESRI 2008 StreetMap data.
Pipelines: Railroad Commission of Texas
Railroads: TNRIS
Stream Crossings: USGS National Hydrography Dataset Flowlines




## Legend

- Alternative 6 Pipeline
- Pipelines
- Railroad
- Electrical Crossing
- Pipeline Crossings
- Stream Crossings
- Railroad Crossings
- Streams, Rivers
- Lakes, Reservoirs
- County Boundary


Location Map

**Figure 4-24d: Identified Crossings**

**Luce Bayou Interbasin Transfer Project**

Path: \\ushou1fp005\cwa\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_4_Figures\Figure 4-24_Identified Crossings.mxd

# 5 Cumulative Effects Analysis




2012

US Army Corps
of Engineers
Galveston District

# Contents

**List of Tables**

# 5.0 CUMULATIVE EFFECTS ANALYSIS (CEA)

This Chapter examines the potential cumulative impacts of the proposed Luce Bayou Interbasin Transfer Project (LBITP). The Cumulative Effects Analysis (CEA) conducted for the proposed project includes information on the background and requirements for the analysis, a description of the methods used to perform the analysis, the resource specific cumulative effects evaluations, and an analysis results summary.

Cumulative impacts are the incremental impacts that the project's direct and indirect effects have on a resource in the context of other past, present, and future effects on a resource from unrelated activities. Cumulative effects to a resource include a project's direct and indirect impacts plus the impacts of other actions not caused by the project. These add to the overall environmental effect, whether adverse or beneficial. The objective of the CEA is to focus on key resource issues, potential effects to these resources, and potential mitigation opportunities.

This CEA was conducted to comply with the Council on Environmental Quality (CEQ) regulations (40 Code of Federal Regulations [CFR] 1500-1508). The CEQ regulations for implementing the National Environmental Policy Act (NEPA) define Cumulative Effects as:

> *"the impact on the environment which results from the incremental impact of the action (project) when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."* (40 CFR 1508.7)

Cumulative effects include direct and indirect, or induced, effects that would result from a project, as well as the effects from other projects (past, present, and reasonably foreseeable future actions) not related to or caused by implementing the project. The CEA considers the magnitude of the cumulative effect would have on the resource (water, plants, animals, etc.) health. Health refers to the resource's general overall condition, stability or vitality and the trend for that condition. Therefore, resource health and trend are key CEA considerations. Laws, regulations, policies, or other factors that may change or sustain the resource trend will be considered to determine if more or less stress on the resource is likely in the foreseeable future. Opportunities to mitigate adverse cumulative effects on a resource or a resource that will be stressed are considered.

The methodology for assessing cumulative impacts of the proposed LBITP is based on the approach outlined in two guidance documents: Texas Department of Transportation (TxDOT) *Guidance on Preparing Cumulative Impact Analyses* (TxDOT 2007) and *Desk Reference for Estimating Indirect Effects of Proposed Transportation Projects* (National Research Council [NRC], 2002).

The eight-step approach described by the TxDOT guidance includes the following:

1) Identify the resources to consider in the analysis
2) Define the study area for each affected resource
3) Describe the current health and historical context for each resource
4) Identify direct and/or the indirect impacts that may contribute to a cumulative impact
5) Identify other reasonably foreseeable actions that may affect a resource
6) Assess potential cumulative effects to each resource
7) Report the results
8) Assess and discuss mitigation issues for all adverse impacts

The following section describes the eight-step approach outlined by the TxDOT *Guidance on Preparing Cumulative Impact Analyses* (TxDOT 2007). The following general resource categories are included in the analysis: physical resources, socio-economic resources, and natural resources. **Table 5-1** summarizes the potential issues, direct effects analysis, and the indirect analyses for the resources and issues analyzed by the LBITP DEIS.

## 5.1 Method Using the TxDOT Eight-Step Process

The TxDOT eight-step process is intended to provide an efficient, consistent, and logical method for evaluating a project's cumulative effects. The following sections describe the eight steps used in this CEA.

### 5.1.1 Step 1: Identify Resources to Consider

Evaluating cumulative effects should be completed for a resource found to be affected by the project. Resources not directly or indirectly impacted by the project are not considered in the CEA. The cumulative impact analysis focuses only on: (1) those resources substantially impacted by the project and (2) resources in poor or declining health or at risk even if the project impacts are relatively small (less than significant).

### 5.1.2 Step 2: Define the Resource Study Area (RSA) for Each Resource

A CEA considers geographic and temporal study limits. An RSA was defined for each resource and is discussed in this document. RSAs were used to characterize the health condition and trend for each resource and to determine the potential cumulative effects on a resource when quantitative information was not available. In addition to spatial boundaries, the various resources were also assigned temporal limits for CEA. The time frame was established as the period from a past environmental reference point, in this case the year used is the mid-1970s, when Houston started planning for and then purchased the CRPS property for the proposed project. The decision by the City of Houston to continue the plans for developing their surface water supplies corresponds to the end of the aggressive 30 year period of reservoirs and dam construction in Texas (1940 to 1970). The future year is 2040, which is the planning design year for the LBITP per Region H RWP. Unless noted in the following RSA sections, the temporal boundaries for the cumulative effects analysis are the mid-1970s to 2040 for all resources.

### 5.1.3 Step 3: Describe the Current Status/Viability and Historical Context for Each Resource

Each resource's historical context and health are described and presented in this document's resource sections. The information establishes the baseline condition and trend for the resource, so the effect's magnitude on the resource can be estimated. The historical context is first described to explain what has caused the resource's current health. As previously mentioned, health refers to the resource's general overall condition, stability, or vitality and the trend for that condition.

Where possible, a quantitative assessment of the current health condition and the trend it is experiencing was provided. However, for many resources, quantitative data were not available to document the resource's current health or trend. For these resources, a qualitative discussion about the resource health and trend is presented, and the types of actions that have caused or influenced resource health and trends are discussed.

**Table 5-1:**
**Summary of Existing Resource Conditions and Potential Impacts**

| Resource – Existing Condition/Current Health | Alternative 1 No Action | Alternative 3A Direct Effects and Significance | Alternative 4 Direct Effects and Significance | Alternative 6 Direct Effects and Significance | Resource Carried Forward for CEA Analysis? |
|---|---|---|---|---|---|
| **Topography and Bathymetry** Section 3.2.2.1 discusses topographical elevations in the project vicinity and surrounding areas. Topography in the study area is affected by the presence of rivers, creeks, bayous and streams (surface water features and associated floodplains), salt domes or salt caverns, roads, agricultural reservoirs and levees, the geology of the Gulf coastal plain, groundwater withdrawals, and subsidence. | No anticipated permanent direct or indirect or significant effects on topography or bathymetry would be anticipated for No Action alternative. | Proposed project is 26.5 miles long within a 300-foot ROW. CRPS construction would affect 90.52 acres and 150 feet along banks of Trinity River. At-grade canal section would directly and permanently affect the topography of approx. 1,050 acres. Pipeline segment would be buried approximately 15 feet below ground surface, directly permanently affecting 40 acres of Capers Ridge. Discharge structure 5 acres in size would be installed below water surface to minimize change to bathymetry of Luce Bayou or Lake Houston. | Proposed project is 23.9 miles long within a 300-foot ROW. Pump station construction would directly and permanently affect an area of xx square feet along banks of Trinity River. Pipeline segment would be buried approximately 15 feet below ground surface, directly permanently affecting 950 acres of area topography. Discharge structure 5 acres in size would be installed below water surface to minimize change to bathymetry of Lake Houston. After construction, restoration of land surface to pre-construction conditions would occur as possible. | Proposed project is 21.4 miles long within a 300-foot ROW. Pump station is already constructed—no additional direct permanent effects would occur along the Trinity River. Pipeline segment would be buried approximately15 feet below ground surface, directly permanently affecting 700 acres of area topography. Discharge structure 5 acres in size would be installed below water surface to minimize change to bathymetry of Lake Houston. After construction, restoration of land surface to pre-construction conditions would occur as possible "The TRPS is constructed along the Trinity River, at an elevation of +26.0 ft mean sea level. The bank of the Trinity River at that location is approx. +26.0 feet above the water surface elevation of 0.0 ft. The bottom of the pumps/pump station intake is located at -15.0 feet relative to mean sea level. | No –Minor change to local topography or bathymetry due to project construction and operation including grading, excavation, land surface or bank stabilization and canal repairs. Current and future resource health condition is not threatened. |
| **Soils** Information about soils is updated periodically by the NRCS. Soil surveys contain information that affects land use planning in survey areas. Soil survey reports identify soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. No specific issues regarding area soils were identified. Note: Prime farmland soils are discussed separately. | Additional direct, indirect and permanent or significant effects to soils or river sediments would not be anticipated for the No Action alternative. | Direct permanent impact to 1,000 acres of surface soils. After construction, restoration of surface soils and re-vegetation of land surface to approximate pre-construction conditions would occur as possible. Soils removed during trenching and additional soils would be used to restore excavations to pre-construction contours. Through hydrodynamic modeling conducted during final design, effect on river morphology and function due to sediment removal would be minimized. | Direct permanent impact to 950 acres of surface soils. After construction, restoration of surface soils and re-vegetation of land surface to approximate pre-construction conditions would occur as possible. Soils removed during trenching and additional soils would be used to restore excavations to pre-construction contours. Through hydrodynamic modeling conducted during final design, effect on river morphology and function due to sediment removal would be minimized. | Direct permanent impact to 700 acres of surface soils. After construction, restoration of surface soils and re-vegetation of land surface to approximate pre-construction conditions would occur as possible. Soils removed during trenching and additional soils would be used to restore excavations to pre-construction contours. | No – Potential project impacts to soils would be minimized. No specific issues regarding area soils were identified. |
| **Prime and Unique Farmland Soils** Overall several decades, large amounts of rural farmland in the Houston region have been converted to developed uses. Loss of prime agricultural land in Texas, the State of Texas is pursuing conservation easements on land, to preserve farms and ranches.<br><br>There are no soils in Texas identified as unique farmland soils. | No direct, indirect permanent or significant effect to prime farmland soils; no direct or indirect effect on unique farmland soils would occur because they are not present in the project vicinity (Liberty or Harris Counties, Texas). | Direct permanent impact to 140 acres of prime farmland soils. Form AD-1006, the Farmland Conversion Impact Rating, was completed to calculate the potential direct permanent impacts to farmland soils. NRCS would need to concur with no effect determination. | Direct permanent impact to 298 acres of prime farmland soils. Form AD-1006, the Farmland Conversion Impact Rating, was completed to calculate the potential direct permanent impacts to farmland soils. NRCS would need to concur with no effect determination | Direct permanent impact to 156 acres of prime farmland soils. Form AD-1006, the Farmland Conversion Impact Rating, was completed to calculate the potential direct permanent impacts to farmland soils. NRCS would need to concur with no effect determination | **Yes** - The proposed project would directly affect prime farmland soils. Development has impacted large areas of farmland in the Houston region, reaching a tipping point for this resource. |

| Resource – Existing Condition/Current Health | Alternative 1 No Action | Alternative 3A Direct Effects and Significance | Alternative 4 Direct Effects and Significance | Alternative 6 Direct Effects and Significance | Resource Carried Forward for CEA Analysis? |
|---|---|---|---|---|---|
| **Geology** Soil characteristics and sediment related to weathering of geologic formations. Sediment transport along area waterways, location of oil, gas, gravel, salt and other natural resources/minerals; favorable areas for underground storage of $CO_2$ in project area related to presence of thick salt beds, mounded salt caverns, domes with the potential for oil and gas accumulation and production. | Oil and gas, mineral, sand and gravel resources would continue to be developed in the project area. ENSTOR Houston HUB storage permitted in project area; other operators also in Liberty County area. Possible additional FERC permitting with operations of the underground natural gas storage of $CO_2$ by underground injection in area of potential project alternatives. Salt dissolution features, sink holes, and minor seismic events possible related to operations of permitted natural gas storage facilities in Liberty County. In addition, groundwater resources would be needed to supplement the water supply and therefore, subsidence would increase affecting local and regional topography. | Regional topography and the overall geologic features would not be permanently affected by this Alternative and local effects would be minimized to the extent possible using site-specific data collection and analyses incorporated into the final design for the proposed LBITP. | Regional topography and the overall geologic features would not be permanently affected by this Alternative and local effects would be minimized to the extent possible using site-specific data collection and analyses incorporated into the final design for the proposed LBITP. | Regional topography and the overall geologic features would not be permanently affected by this Alternative and local effects would be minimized to the extent possible using site-specific data collection and analyses incorporated into the final design for the proposed LBITP. | No. Potential project impacts to geology would be minimized during final design. |
| **Sedimentation and erosion** Hydrogeomorphic changes could include landscape changes caused by active processes including erosion, fluvial sediment deposition, intensity, and location of currents, wave, and tidal action. | Direct permanent impact to geomorphology other than natural occurrences not anticipated for No Action alternative. | Through hydrodynamic modeling conducted during final design, effect on river morphology and function due to sediment removal would be minimized. | Through hydrodynamic modeling conducted during final design, effect on river morphology and function due to sediment removal would be minimized. | Through hydrodynamic modeling conducted during final design, effect on river morphology and function due to sediment removal would be minimized. | No Potential project impacts to sedimentation and erosion per hydrodynamic modeling and sediment studies would be minimized during final design (see Appendix I |
| **Subsidence** Geologic hazards in vicinity of project area; fault movement not considered potentially significant.<br><br>Subsidence affects landscape elevation, could increase flooding, and combined with sea level rise, could inundate larger area compared to baseline. | Direct or indirect permanent effects on area faulting not anticipated for No Action alternative. If groundwater resources are not replaced by surface water sources, subsidence of the Houston area would continue as part of No Action; groundwater resources would continue to be used to supply municipal water needs of Region H. The Harris-Galveston and Fort Bend Subsidence District Plans for management and control of land subsidence would not be achieved by regulatory deadlines. | Subsidence would be projected to continue to decline from conversion to surface water supply as Harris-Galveston and Fort Bend County Subsidence District Plans for regulatory schedule for surface water conversion would continue to be implemented throughout Houston ETJ. | Subsidence would be projected to continue to decline from conversion to surface water supply as Harris-Galveston and Fort Bend County Subsidence District Plans for regulatory schedule for surface water conversion would continue to be implemented throughout Houston ETJ. | Subsidence would be projected to continue to decline from conversion to surface water supply as Harris-Galveston and Fort Bend County Subsidence District Plans for regulatory schedule for surface water conversion would continue to be implemented throughout Houston ETJ. | No. Potential project impacts to subsidence would be minimized during final design. |
| **Climate and Climate Change** | Regional climate and climate change could or would occur as anticipated by climate change scientists; additional direct, indirect, and permanent significant effects related to sea level rise (increase) exacerbated by continued groundwater withdrawals to meet water demands would permanently and adversely cause changes to local hydrology, increase in flood potential and flood hazards as a result of climate or climate change as a result of the No Action alternative. | Regional climate and climate change could or would occur as anticipated by climate change scientists; additional direct, indirect, and permanent significant effects related to sea level rise (increase) and area subsidence would permanently and adversely cause changes to local hydrology, increase in flood potential and flood hazards as a result of climate or climate change in the vicinity of Galveston Bay. | Regional climate and climate change could or would occur as anticipated by climate change scientists; additional direct, indirect, and permanent significant effects related to sea level rise (increase) and area subsidence would permanently and adversely cause changes to local hydrology, increase in flood potential and flood hazards as a result of climate or climate change in the vicinity of Galveston Bay.. | Regional climate and climate change could or would occur as anticipated by climate change scientists; additional direct, indirect, and permanent significant effects related to sea level rise (increase) and area subsidence would permanently and adversely cause changes to local hydrology, increase in flood potential and flood hazards as a result of climate or climate change in the vicinity of Galveston Bay.. | No. Project related effects could occur and may include changes in vegetation patterns as climate changes or an increase in flooding caused by an increase in subsidence coupled with sea level rise, but effects are not quantifiable or controllable on a project-specific level. |

| Resource – Existing Condition/Current Health | Alternative 1<br>No Action | Alternative 3A<br>Direct Effects and Significance | Alternative 4<br>Direct Effects and Significance | Alternative 6<br>Direct Effects and Significance | Resource Carried Forward for CEA Analysis? |
|---|---|---|---|---|---|
| **Air Quality (**see **Appendix Q** for AECOM reports on air emissions during construction, GHG emissions analyses and discussion on air conformity**)** | Air quality would not be expected to be adversely affected or benefit from the implementation of the No Action Alternative. | Based on the information provided in the construction estimate and the associated emissions estimate provided, the LBITP alternatives are expected to conform to current emissions. Emissions for the other pollutants emitted as a result of Alternative 3A are below the emission threshold. | Based on the information provided in the construction estimate and the associated emissions estimate provided, the LBITP alternatives are expected to conform to current emissions requirements with one exception. Alternative 4 is estimated to have emissions of NOx that exceed the EPA screening threshold. Emissions for the other pollutants emitted during construction of Alternative 4 are below the emission threshold. As this was a screening analysis based on extrapolating from the proposed project construction schedule, the analysis does not indicate that Alternative 4 is an unacceptable alternative; rather, it indicates that if Alternative 4 were to be selected, a more detailed air quality analysis would be needed to verify conformance with current emission requirements (AECOM 2012; **Appendix Q**). | Based on the information provided in the construction estimate and the associated emissions estimate provided, the LBITP alternatives are expected to conform to current air emissions requirements. Emissions for the other pollutants emitted as a result of Alternative 6 are below the emission threshold (AECOM 2012; **Appendix Q**). | No. Potential project impacts to air quality would be minimized during final design and construction such that efforts would be made to control dust, use of toxic air pollutants, and to limit GHG emissions and ozone precursors related to use of diesel-powered and gasoline-powered equipment. Consideration would be given to the use of low-sulfur diesel fuels, and use of EPA compliant equipment and engine controls, as necessary. |
| **Greenhouse Gas (GHG) Emissions** | No anticipated permanent direct or indirect significant effects on GHG emissions would be anticipated for No Action alternative. | The results of the GHG emissions compliance analysis indicate that the LBITP would not violate these standards and total ambient pollutant concentrations levels would remain well below applicable limits (**Appendix Q**). | The results of the GHG emissions compliance analysis indicate that the LBITP would not violate these standards and total ambient pollutant concentrations levels would remain well below applicable limits (**Appendix Q**). | The results of the GHG emissions compliance analysis indicate that the LBITP would not violate these standards and total ambient pollutant concentrations levels would remain well below applicable limits (**Appendix Q**) | No. Potential project controls related to the emission of GHGs would be minimized during final design and construction such that efforts would be made to minimize the use of toxic air pollutants, and to limit GHG emissions and ozone precursors related to use of diesel-powered and gasoline-powered equipment. |
| **Hazardous Air Pollutants** | No anticipated permanent direct or indirect or significant effects on HAPs would be anticipated for No Action alternative. | The results of the hazardous air pollutant compliance analysis indicate that the LBITP would not violate these standards and total ambient pollutant concentrations levels would remain well below applicable regulatory limits. | The results of the hazardous air pollutant compliance analysis indicate that the LBITP would not violate these standards and total ambient pollutant concentrations levels would remain well below applicable limits. | The results of the hazardous air pollutant compliance analysis indicate that the LBITP would not violate these standards and total ambient pollutant concentrations levels would remain well below applicable limits | No. Potential project impacts to air quality would be minimized during final design and construction such that efforts would be made to control dust, use of toxic air pollutants, and to limit GHG emissions and ozone precursors related to use of diesel-powered and gasoline-powered equipment. Consideration would be given to the use of low-sulfur diesel fuels, and use of EPA compliant equipment and engine controls, as necessary. |
| **Surface Water Resources** | Surface water resources would not be directly affected without the construction of the LBITP with the exception that additional sources of water supply would be needed sooner than anticipated by the Region H RWP. Without the proposed project, groundwater resources would likely be needed to supply Houston water needs. Surface water resources in the project area would not be affected. | There would be significant, direct, long-term effect on the lower Trinity River and Lake Houston as a result of the implementation of the LBITP. Perennial and intermittent streams would be affected for a distance of 19,873 linear feet along the proposed alternative alignment. Approximately 4.9 acres of open water resources would be directly affected. Bottomland impacts total 1.5 acres. | There would be significant, direct, long-term effect on the lower Trinity River and Lake Houston as a result of the implementation of the LBITP. Cedar Bayou would also be directly impacted by the proposed installation of the Alternative 4 pipeline through the Cedar Bayou watershed and floodplain. Perennial and intermittent streams would be affected for a distance of 20,471 linear feet along the proposed alternative alignment. Approximately 4.5 acres of open water resources would be directly affected. Bottomland impacts total 3.9 acres. | There would be significant, direct, long-term effect on the lower Trinity River and Lake Houston as a result of the implementation of the LBITP. Cedar Bayou would also be directly impacted by the proposed installation of the Alternative 6 pipeline through the Cedar Bayou watershed and floodplain. Perennial and intermittent streams would be affected for a distance of 15,794 linear feet along the proposed alternative alignment. Approximately 0.9 acres of open water resources would be directly affected. Bottomland impacts total 11.3 acres. | **Yes--evaluated through the analyses conducted for the floodplain RSA** |
| **Water Quality** | Without the proposed project, the LBITP would not be constructed and water quality of the lower Trinity River, Lake Houston, would not be affected when compared with baseline. | There would be a potential minor long-term beneficial effect on the water quality of Lake Houston as a result of the implementation of the LBITP. | There would be a potential minor long-term beneficial effect on the water quality of Lake Houston as a result of the implementation of the LBITP. The water quality of Cedar Bayou would also be directly impacted by the proposed installation of the Alternative 4 pipeline through the Cedar Bayou watershed and floodplain. | There would be a potential minor long-term beneficial effect on the water quality of Lake Houston as a result of the implementation of the LBITP. The water quality of Cedar Bayou would also be directly impacted by the proposed installation of the Alternative 6 pipeline through the Cedar Bayou watershed and floodplain. | No. No effects to water quality as a result of the proposed project are anticipated. |

| Resource – Existing Condition/Current Health | Alternative 1 No Action | Alternative 3A Direct Effects and Significance | Alternative 4 Direct Effects and Significance | Alternative 6 Direct Effects and Significance | Resource Carried Forward for CEA Analysis? |
|---|---|---|---|---|---|
| **Surface Water Hydrology and Drainage** | Without the proposed project, the LBITP would not be constructed and surface water hydrology and drainage of the lower Trinity River, Luce Bayou, Lake Houston, would not be affected when compared with baseline. | Although mitigation would occur, and overland flow maintained by siphon structures, there would be a direct, long-term & permanent effect on surface water hydrology and drainage of the San Jacinto, Cedar Bayou, lower Trinity River and Galveston Bay as a result of the implementation of the LBITP. Approximately 4.9 acres of floodplain, 6.6 acres of floodway, would be directly affected by canal construction. | Although mitigation would occur, and overland flow maintained by siphon structures, there would be a direct, long-term & permanent effect on surface water hydrology and drainage of the San Jacinto, Cedar Bayou, lower Trinity River and Galveston Bay as a result of the implementation of the LBITP. The surface water hydrology and drainage of the Cedar Bayou watershed/floodplain would also be directly impacted by the proposed installation of the Alternative 4 pipeline through the Cedar Bayou watershed and floodplain. Approximately 78.6 acres of floodplain, 91.6 acres of floodway, would be directly affected by proposed pipeline construction. | Although mitigation would occur, and overland flow maintained by siphon structures, there would be a direct, long-term & permanent effect on surface water hydrology and drainage of the San Jacinto, Cedar Bayou, lower Trinity River and Galveston Bay as a result of the implementation of the LBITP. The surface water hydrology and drainage of the Cedar Bayou watershed/floodplain of Cedar Bayou would also be directly impacted by the proposed installation of the Alternative 6 pipeline through the Cedar Bayou watershed and floodplain. Approximately 96.1 acres of floodplain, 15.8 acres of floodway, would be directly affected by proposed pipeline construction. | **Yes--evaluated through the analyses conducted for the floodplain RSA** |
| **Watershed Management** | Without the proposed project, the LBITP would not be constructed and water quality of the lower Trinity River, Lake Houston, would not be affected when compared with baseline. | Although mitigation would occur, and overland flow maintained by siphon structures, there would be a direct, long-term & permanent effect on the functioning and management of the watersheds of the San Jacinto, Cedar Bayou, lower Trinity River and Galveston Bay as a result of the implementation of the LBITP | Although mitigation would occur, and overland flow maintained by siphon structures or similar structures that would be identified during preliminary and final design, there would be a direct, long-term, & permanent effect on surface water hydrology and drainage of the San Jacinto, Cedar Bayou, lower Trinity River, and Galveston Bay result of the implementation of the LBITP. The surface water hydrology and drainage of the Cedar Bayou watershed/floodplain would also be directly impacted by the proposed installation of the Alternative 4 pipeline through the Cedar Bayou watershed and floodplain. | Although mitigation would occur, and overland flow maintained by siphon or similar structures that would be identified during preliminary and final design, there would be a direct, long-term, & permanent effect on surface water hydrology and drainage of the San Jacinto, Cedar Bayou, lower Trinity River, and Galveston Bay result of the implementation of the LBITP. The surface water hydrology and drainage of the Cedar Bayou watershed/floodplain of Cedar Bayou would also be directly impacted by the proposed installation of the Alternative 6 pipeline through the Cedar Bayou watershed and floodplain. | **Yes—evaluated using the floodplain RSA** |
| **Flood Hazards and Floodplain Values** | Without the proposed project, the LBITP would not be constructed and flood hazards and floodplain values would not be affected when compared with baseline conditions. | Although mitigation would occur, and overland flow/floodplain values maintained by siphon structures to reduce the potential for flood hazards, there would be a direct, long-term & permanent effect on the functioning and management of the watersheds of the San Jacinto, Cedar Bayou, lower Trinity River and Galveston Bay as a result of the implementation of the LBITP. The proposed project would be constructed within 54 acres floodplain/floodways. Flood hazards and floodplain values of the Cedar Bayou watershed, 5 acres in extent, and within the downstream Luce Bayou watershed would also be directly impacted by the proposed project which may directly impact Lake Houston and indirectly Galveston Bay. | Although mitigation would occur, and overland flow/floodplain values maintained by siphon structures to reduce the potential for flood hazards, there would be a direct, long-term & permanent effect on the functioning and management of the watersheds of the San Jacinto, Cedar Bayou, lower Trinity River and Galveston Bay as a result of the implementation of the LBITP. The proposed project would be constructed within 170 acres floodplain/floodways. Flood hazards and floodplain values of the Cedar Bayou watershed would also be directly and negatively impacted by the proposed installation of the Alternative 4 pipeline which would also indirectly affect Galveston Bay. | Although mitigation would occur, and overland flow/floodplain values maintained by siphon structures to reduce the potential for flood hazards, there would be a direct, long-term & permanent effect on the functioning and management of the watersheds of the San Jacinto, Cedar Bayou, lower Trinity River and Galveston Bay as a result of the implementation of the LBITP. The proposed project would be constructed within 112 acres floodplain/floodways. Flood hazards and floodplain values of the Cedar Bayou watershed would also be directly and negatively impacted by the proposed installation of the Alternative 6 pipeline which would also indirectly affect Galveston Bay. | **Yes— evaluated using the floodplain RSA** |
| **Groundwater** Changes from groundwater to surface water supplies (i.e., the source of public water supply), in groundwater flow patterns, groundwater pollution or effects to springs and seeps. Detention basins should be designed to control outflow and the bottom of the detention basin, including underdrain soil filters, should be above the seasonal high groundwater table. | Without the proposed project, groundwater resources would be needed to supply Houston water needs. Groundwater would be used to an extent greater than allowed by regional subsidence management plans. Groundwater resources would be impacted by withdrawals exceeding capacity for aquifer to recharge; groundwater quality and quantity would degrade with time. | By implementing the proposed project, regional groundwater resources would directly and indirectly permanently benefit through conversion to surface water supply sources. Alternative 3A's construction, operation, and maintenance would not be expected to affect groundwater availability in the project area. | By implementing the proposed project, regional groundwater resources would directly and indirectly permanently benefit through conversion to surface water supply sources. Alternative 4's construction, operation, and maintenance would not be expected to affect groundwater availability in the project area. | By implementing the proposed project, regional groundwater resources would directly and indirectly permanently benefit through conversion to surface water supply sources. Alternative 6's construction, operation, and maintenance would not be expected to affect groundwater availability in the project area. The detention basin bottom should be located above the seasonal high groundwater table to avoid standing water in the basin. | No |

| Resource – Existing Condition/Current Health | Alternative 1 No Action | Alternative 3A Direct Effects and Significance | Alternative 4 Direct Effects and Significance | Alternative 6 Direct Effects and Significance | Resource Carried Forward for CEA Analysis? |
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| **Historic and Architectural Resources** Result in the loss of historic or architectural resources. | No anticipated permanent direct or indirect or significant effects on historic and architectural Resources would be anticipated for No Action alternative. | Two potentially historic areas were identified within the Area of Potential Effect (APE). However, no direct effects are anticipated for construction, operation, or maintenance.<br><br>The proposed Alternative 3A ROW follows property lines of residential properties and identified historic properties or sites were avoided during project planning and no mitigation is therefore needed for historic resources. | No site specific field investigations were conducted for Alternative 4; however, limited records investigation were conducted as described in **Chapter 3.14** and in the above section. In addition, a review of Texas Sites Atlas electronic records of the Texas Historical Commission was also conducted. This review indicated that no previously recorded historic sites are located within the Alternative 4 ROW alignment. | No site specific field investigations were conducted for Alternative 6; however, limited records investigation were conducted as described in Chapter 3.14 and in the above section. In addition, a review of Texas Sites Atlas electronic records of the Texas Historical Commission was also conducted. This review indicated that no previously recorded historic sites are located within the Alternative 6 ROW alignment. | No. No historic or architectural resources have been identified for the proposed project. |
| **Archeological Resources** Result in the loss of paleontological and archeological resources. | No anticipated permanent direct or indirect or significant effects on archeological resources would be anticipated for No Action alternative. | Based on the investigations conducted, approximately 30 newly-recorded prehistoric (Native American) archeological sites have been identified within the area of potential effect of Alternative 3A. The results of intensive pedestrian surveys, supplemental field work, and data review have been compiled and submitted to the THC (Texas Historical Commission) SHPO (State Historical Preservation Officer) for a determination of findings. Through continued coordination with the SHPO, it is anticipated that Alternative 3A would result in permanent, minor effect on cultural resources.<br><br>After construction, operation and maintenance of the proposed project would not be expected to | No site specific archeological investigations were conducted for Alternative 4; however data and records research was conducted and conservation assumptions regarding the potential for encountering archeological resources have been integrated into project planning to the extent possible (PALM developed). No prehistoric archeological sites have been documented within the Alternative 4 ROW alignment. A pedestrian archeological survey, including shovel testing and/or backhoe trenching where appropriate would be recommended, as needed.<br><br>It is recommended that coordination with the SHPO be conducted in order to avoid and minimize effects to archeological resources as a result of the construction of Alternative 4. It is anticipated that Alternative 4 may result in permanent, minor effect on cultural resources that may occur during construction. | No site specific archeological investigations were conducted for Alternative 6; however data and records research was conducted and conservation assumptions regarding the potential for encountering archeological resources have been integrated into project planning to the extent possible (PALM developed). No historic or prehistoric archeological sites have been documented within the Alternative 6 ROW alignment.<br><br>The Alternative 6 ROW alignment crosses through two major streams, Cedar Bayou and Gum Gully, and also crosses through the lower Trinity River and San Jacinto River floodplains on the east and west. Archeological resources may be present in the wide floodplain at the western end of the Alternative 6 ROW near Lake Houston. For the Alternative 6 ROW alignment, this route contains four points at which it crosses major streams that would likely require mechanical trenching to prospect for deeply buried sites; these areas of potential archeological liability total at least 30 percent of the existing alignment. A pedestrian archeological survey, including shovel testing and/or backhoe trenching where appropriate, for specific areas identified near streams would be recommended, as needed.<br><br>It is recommended that coordination with the SHPO be conducted in order to avoid and minimize effects to archeological resources as a result of the construction of Alternative 6. It is anticipated that Alternative 6 may result in permanent, minor effect on cultural resources that may occur during construction. | No. Archeological resources are under investigation and compliance with the National Historic Preservation Act would be coordinated between the SHPO and USACE Galveston District for any of the alternatives considered for implementation to avoid, minimize, and then mitigate for effects to these resources. Mitigation may include the development of an Unanticipated Discoveries Plan. |

| Resource – Existing Condition/Current Health | Alternative 1<br>No Action | Alternative 3A<br>Direct Effects and Significance | Alternative 4<br>Direct Effects and Significance | Alternative 6<br>Direct Effects and Significance | Resource Carried Forward for CEA Analysis? |
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| **Air Quality and Conformity** | No anticipated permanent direct or indirect or significant effects on air quality and conformity would be anticipated for No Action alternative. | Air emissions would be generated from construction, operation and maintenance activities, vehicle traffic, and at the maintenance facility. Potential impacts would be temporary and would be minimized through use of BMPs soil wetting, covering trucks and stored materials with tarp to reduce windborne dust, and using of properly maintained equipment. LBITP would not be a new air pollution source. | Air emissions would be generated from construction, operation and maintenance activities, vehicle traffic, and at the maintenance facility. Potential impacts would be temporary and would be minimized through use of BMPs soil wetting, covering trucks and stored materials with tarp to reduce windborne dust, and using of properly maintained equipment. LBITP would not be a new air pollution source. | Air emissions would be generated from construction, operation and maintenance activities, vehicle traffic, and at the maintenance facility. Potential impacts would be temporary and would be minimized through use of BMPs soil wetting, covering trucks and stored materials with tarp to reduce windborne dust, and using of properly maintained equipment. LBITP would not be a new air pollution source. | No. No air conformity issues are related to potential air quality effects of stationary sources. |
| **Coastal Resources and Hazards** | No anticipated permanent direct or indirect or significant effects on coastal resources and hazards would be anticipated for No Action alternative. | No anticipated permanent direct or indirect or significant effects on coastal resources and hazards would be anticipated for Alternative 3A. | No anticipated permanent direct or indirect or significant effects on coastal resources and hazards would be anticipated for Alternative 4. | No anticipated permanent direct or indirect or significant effects on coastal resources and hazards would be anticipated for Alternative 6. | No. No anticipated permanent direct significant effects on coastal resources and hazards would be anticipated for the LBITP. |
| **Population and Housing** | The No Action Alternative would have an economic effect on population and housing as insufficient water sources are used to meet projected water demand. | Alternative 3A would predominantly traverse undeveloped and agricultural land. There would be no impacts to population or housing as a result of the project's implementation. | Alternative 4 would predominantly traverse agricultural, industrial, and residential land. There would be impacts to population or housing as a result of the project's implementation. | Alternative 6 would predominantly traverse agricultural, industrial, and residential land. There would be impacts to population or housing as a result of the project's implementation. | No. For Alternative 3A, no adverse, long-term effects to population and housing would be expected. For Alternatives 4 and 6, desk-top studies were conducted to evaluate the potential for impacts to population and housing. Refinement of these findings would be needed during preliminary and final design to avoid and minimize these potential direct, indirect, and adverse effects are area populations. |
| **Environmental Justice /Social Values** | The No Action Alternative would have no impact on existing environmental justice populations. Regionally the impact to environmental justice communities could be impacted by decrease of water supply. | The proposed project could impact any minority or low-income residents being displaced by Alternative 3A. One census block which a high minority population (i.e., greater than 50 percent) would be impacted by property acquisition (up to 25 people), as discussed in Section 4.10.1. Based on the study conducted, adverse and disproportionate impacts would be anticipated. Aesthetic, visual, and temporary noise impacts as discussed in *Sections 4.11.2* and *4.14* would have minor short-term impacts during construction. | The proposed project could directly, adversely and permanently impact minority or low-income residents being displaced by Alternative 4. Three census blocks have high minority population (i.e., greater than 50 percent) where property acquisition would take place and approximately 4,033 minority residents of Liberty and Harris County could be affected as discussed in Section 4.10.1. Based on the study conducted, adverse and disproportionate impacts would be anticipated. Aesthetic and visual and temporary noise impacts as discussed in *Sections 4.11.2* and *4.14* would have minor short-term impacts during construction. | The proposed project could directly, adversely and permanently impact minority or low-income residents being displaced by Alternative 6. Three census blocks have high minority populations (i.e., greater than 50 percent) where property acquisition would take place and 322 minority residents of Liberty and Harris County could be affected as discussed in Section 4.10.1. Based on the study conducted, adverse and disproportionate impacts would be anticipated. Aesthetic and visual and temporary noise impacts as discussed in *Sections 4.11.2* and *4.14* would have minor short-term impacts during construction. | No. The potential direct and indirect, long-term and adverse effect to potential EJ populations could occur for the implementation of the LBITP. For Alternatives 4 and 6, desk-top studies were conducted to evaluate the potential for impacts to these EJ populations. However, detailed alignment and routing studies would likely be performed during final design to minimize these effects. For this reason, EJ and social value resources are not carried forward into the CEA. |
| **Economics** | There would be no direct effects to economic resources as a result of No Action. Indirect economic impacts of a decreased water supply would include likely curtail or change the economic activity in business and industries heavily reliant on water. Without water, farmers cannot irrigate; refineries cannot produce gasoline, paper mills cannot make paper and the public would not have adequate supplies of drinking water from surface water sources. | Loss of income and tax revenue from change of land use from agricultural and timber production to public use. The total economic loss of net income foregone as a result of the change to public use is $8,782 or 5.8% of the total economic value of the properties within the ROW. There are 34 properties that provide economic value through agricultural and timber production within the ROW. Tax revenue is assessed at 8% per $1,000 per acre property. | Loss of income and tax revenue from change of land use from agricultural and timber production to public use. The total economic loss of net income foregone as a result of the change to public use is $2,315 or 1.8% of the total economic value of the properties within the ROW. There are 79 properties that provide economic value through agricultural and timber production within the ROW. | Loss of income and tax revenue from change of land use from agricultural and timber production to public use. The total economic loss of net income foregone as a result of the change to public use is $22,066 or 24.4% of the total economic value of the properties within the ROW. There are 25 properties that provide economic value through agricultural and timber production within the ROW. | **Yes – Both positive and negative economic impacts are anticipated as result of the proposed project.** |

| Resource – Existing Condition/Current Health | Alternative 1 No Action | Alternative 3A Direct Effects and Significance | Alternative 4 Direct Effects and Significance | Alternative 6 Direct Effects and Significance | Resource Carried Forward for CEA Analysis? |
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| **Water Supply and Conservation** | No Action would not allow the City of Houston to maintain their plans to provide water to their customers as stipulated by the contracts they have with regional water providers. Water supply and conservation measures would need to be taken at a level unanticipated by the Region H RWP. Lack of water supply would result in mandatory, widespread, and detrimental conservation measures. | Alternative 3A would provide a public benefit with respect to water supply. The LBITP is a long-planned project identified by the State of Texas as critical to providing water to meet projected population growth of Houston. The need for the LBITP is to meet projected water requirements as exemplified by Water Supply Contracts held between the Houston and NHCRWA, CHCRWA, WHCRWA, and NFBWA for future water. A secondary objective is to assist with the conversion from groundwater to surface water sources to meet mandated goals developed to control area subsidence. Without the LBITP, the City of Houston would not be able to meet its contracted demand allocations, projected long-term water supply requirements identified by the 2011 Region H RWP and the TWDB 2012 State Water Plan; and would not be able to meet mandated conversion of groundwater to surface water supply sources to control area subsidence by the mandated conversion dates imposed by HGSD and the Fort Bend Subsidence District. | Alternative 4 would provide a public benefit with respect to water supply. The LBITP is a long-planned project identified by the State of Texas as critical to providing water to meet projected population growth of Houston. The need for the LBITP is to meet projected water requirements as exemplified by Water Supply Contracts held between the Houston and NHCRWA, CHCRWA, WHCRWA, and NFBWA for future water. A secondary objective is to assist with the conversion from groundwater to surface water sources to meet mandated goals developed to control area subsidence. Without the LBITP, the City of Houston would not be able to meet its contracted demand allocations, projected long-term water supply requirements identified by the 2011 Region H RWP and the TWDB 2012 State Water Plan; and would not be able to meet mandated conversion of groundwater to surface water supply sources to control area subsidence by the mandated conversion dates imposed by HGSD and the Fort Bend Subsidence District. | Alternative 6 would provide a public benefit with respect to water supply. The LBITP is a long-planned project identified by the State of Texas as critical to providing water to meet projected population growth of Houston. The need for the LBITP is to meet projected water requirements as exemplified by Water Supply Contracts held between the Houston and NHCRWA, CHCRWA, WHCRWA, and NFBWA for future water. A secondary objective is to assist with the conversion from groundwater to surface water sources to meet mandated goals developed to control area subsidence. Without the LBITP, the City of Houston would not be able to meet its contracted demand allocations, projected long-term water supply requirements identified by the 2011 Region H RWP and the TWDB 2012 State Water Plan; and would not be able to meet mandated conversion of groundwater to surface water supply sources to control area subsidence by the mandated conversion dates imposed by HGSD and the Fort Bend Subsidence District. | No |
| **Housing** Alteration in housing due to project implementation. | The No Action Alternative would have no impact on housing other than market forces that would necessitate those changes. | Depending on the resolution of the relocation of a cell tower in the vicinity of FM 321, Alternative 3A could have one residential housing relocation and family displacement. | Alternative 4 would permanently displace 63 residences, directly and permanently adversely affecting housing resources, and would result in 69 relocations. | Alternative 6 would permanently displace 36 residences, directly and permanently adversely affecting housing resources, and 48 relocations would occur. | No |
| **Public Facilities and Services** Water supply, police, fire, hospitals, EMT services. | No Action would not allow the City of Houston to maintain their plans to provide water to their customers as stipulated by the contracts they have with regional water providers. Public services related to water would be impacted. Other public resources such as police, hospitals may be indirectly affected by limited availability of water as would fire protection systems under No Action. | Alternative 3A would provide a public benefit with respect to water supply. The LBITP is a long-planned project identified by the State of Texas as critical to providing water to meet projected population growth of Houston. Providing additional water supply should ensure the availability water resources for emergency response personnel. | Alternative 4 would provide a public benefit with respect to water supply. The LBITP is a long-planned project identified by the State of Texas as critical to providing water to meet projected population growth of Houston. Providing additional water supply should ensure the availability of water resources for emergency response personnel. | Alternative 6 would provide a public benefit with respect to water supply. The LBITP is a long-planned project identified by the State of Texas as critical to providing water to meet projected population growth of Houston. Providing additional water supply should ensure the availability water resources for emergency response personnel. | No |
| **Utilities and Pipelines** Electrical power corridors and oil and gas pipelines. | The No Action Alternative would have no impact on utilities and pipelines in the project area. | No electrical power corridors were identified as crossing the ROW of proposed Alternative 3A. | Approximately 19 electrical power corridors were identified as crossing the ROW of proposed Alternative 4.<br><br>Approximately 24 oil and gas pipelines either intersect or are in the vicinity of the proposed Alternative 4. | Approximately 10 electrical power corridors cross the proposed ROW of Alternative 6.<br><br>Approximately 65 oil and gas pipelines either intersect or are in the vicinity of the proposed Alternative 6. | No |

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| **Community Cohesion** Alteration in access to community resources and impact to the community cohesion as a result of the proposed project. | The No Action Alternative would have no impact on community cohesion. | Alternative 3A would predominantly traverse undeveloped and agricultural land. The project does not isolate communities. There would be no impacts to community cohesion as a result of the project's implementation. The proposed, fenced canal easement with access road and associated facilities would cross through agricultural fields and undeveloped areas for much of the length of the alignment. Near Lake Houston and Luce Bayou discharge, in the vicinity of FM 2100 and Wolff Road, several residential subdivisions or planned residential areas would be traversed. The bermed and elevated canal section would cause a linear, unbroken visual and travel barrier to the existing and future planned communities. | Alternative 6 pipeline alternative is 23.9 miles long within a 300-foot, fenced ROW. Alternative 4 would predominantly traverse undeveloped, agricultural land, with some residential land use. Approximately 63 residences would be directly and permanently affected by Alternative 4. The proposed, fenced pipeline easement with access road and associated facilities would cross through several residential subdivisions resulting in a linear, unbroken visual and travel barrier to these communities. There would be direct and indirect effects to community cohesion as a result of the project's implementation. | Alternative 6 pipeline alternative is 21.4 miles long within a 300-foot, fenced ROW. Alternative 6 would predominantly traverse undeveloped, agricultural, and developed industrial and residential land and 36 residences would be directly and permanently affected by Alternative 6. The proposed, fenced pipeline easement with access road and associated facilities would cross through several residential subdivisions and industrial developed areas resulting in a linear, unbroken visual and travel barrier to these communities. There would be direct and indirect effects to community cohesion as a result of the project's implementation. | No |
| **Relocations and Displacements** | The No Action Alternative would not result in any relocations or displacements. | Depending on the resolution of the relocation of a cell tower in the vicinity of FM 321, Alternative 3A could have at most one relocation and family displacement. | Alternative 4 would permanently displace 63 residences and result in 69 relocations would occur. | Alternative 6 would permanently displace 36 residences and 48 relocations would occur. | No |
| **Land Use Planning and Policies** Conformance with regional and/or local government land use plans or policies | The No Action Alternative would not require any changes to land use planning policy. | Local plans would have to update any references to infrastructure in the region as a result of the implementation of the proposed project. | Local plans would have to update any references to infrastructure in the region as a result of the implementation of the proposed project. | Local plans would have to update any references to infrastructure in the region as a result of the implementation of the proposed project. | No |
| **Local and Regional Land Use** Changes in existing local or regional land use | The No Action Alternative would not require any changes to existing land use. | Land use impacts would include changes from agricultural and residential properties to public land. For example, if the project impacts a residential parcel, its use will be altered to public land use. The 3,000 acre proposed mitigation property would change from private to public ownership. | Land use impacts would include changes from agricultural and residential properties to public land. For example, if the project impacts a residential parcel, its use will be altered to public land use. The 3,000 acre proposed mitigation property would change from private to public ownership. | Land use impacts would include changes from agricultural, industrial, and residential properties to public land. For example, if the project impacts an industrial area, the 300-foot easement within the proposed ROW would change to public land use. The 3,000 acre proposed mitigation property would change from private to public ownership. | No |
| **Land Use Controls and Zoning** No zoning requirements have been identified, conformance with land use controls and zoning | There are no zoning or land use controls in the project study area. | There are no zoning or land use controls in the project study area. | There are no zoning or land use controls in the project study area. | There are no zoning or land use controls in the project study area. | No |
| **Land Use Conflicts** Conformance with local plans or laws, regulations, or rules and operating rules for Lake Houston, Lake Wallisville, and Lake Livingston in accordance also with water rights permits and diversion amounts and locations. | There would be no land use conflicts that would occur under No Action. | Alternative 3A would comply with local plans or laws, regulations, or rules and operating rules for Lake Houston, Lake Wallisville, and Lake Livingston in accordance also with water rights permits and diversion amounts and locations. | Alternative 4 would comply with local plans or laws, regulations, or rules and operating rules for Lake Houston, Lake Wallisville, and Lake Livingston in accordance also with water rights permits and diversion amounts and locations. | Alternative 6 would comply with local plans or laws, regulations, or rules and operating rules for Lake Houston, Lake Wallisville, and Lake Livingston in accordance also with water rights permits and diversion amounts and locations. | No |
| **Public Lands** | The No Action Alternative would result in no effect on public lands compared to baseline conditions. | Approximately 3,000-acres of property would benefit from Federal protection as it would be transferred to the Trinity River National Wildlife Refuge System for public use as a result of the LBITP. Approximately 1,000 acres of property would change from private to public use. | Approximately 3,000-acres of property would benefit from Federal protection as it would be transferred to the Trinity River National Wildlife Refuge System for public use as a result of the LBITP. Approximately 950 acres of property would change from private to public use. | Approximately 3,000-acres of property would benefit from Federal protection as it would be transferred to the Trinity River National Wildlife Refuge System for public use as a result of the LBITP. Approximately 700 acres of property would change from private to public use. | No |
| **Hazardous Materials and Hazardous Wastes** | The No Action Alternative would result in no impact to hazardous material and waste. | None identified within 1,000 feet of the Alternative 3A ROW. | None identified within 1,000 feet of the Alternative 4 ROW. | None identified within 1000 feet of the Alternative 6 ROW. | No |
| **Traffic and Transportation, Traffic Circulation Patterns** | The No Action Alternative would not require any changes to the transportation and traffic network. | No long-term permanent adverse direct impacts to the roadway network are anticipated. | No long-term permanent adverse direct impacts to the roadway network are anticipated. | No long-term permanent adverse direct impacts to the roadway network are anticipated. | No |

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| **Aesthetics and Visual Resources** | Under this alternative, the visual environment would remain essentially the same except as changes occur over time at individual properties. | Direct impacts from Alternative 3A include the aesthetics of the riparian tree line along the Trinity River; view shed where project elements such as the maintenance facility and any elevated structures are implemented; and the removal of vegetation along the project view shed. The proposed, fenced canal easement with access road and associated facilities would cross through agricultural fields and undeveloped areas for much of the length of the alignment. Near Lake Houston and Luce Bayou discharge, in the vicinity of FM 2100 and Wolff Road, several residential subdivisions or planned residential areas would be traversed. The bermed and elevated canal section would cause a linear, unbroken visual and aesthetic barrier (negatively impacting the area) to the existing and future planned communities. | Direct impacts from Alternative 4 include the disruption of the view shed from project elements such as the maintenance facility and any elevated structures; change in use of pastureland or agricultural land; and the removal of vegetation along the project view shed. The proposed, fenced pipeline easement with access road and associated facilities would cross through agricultural fields and undeveloped areas for much of the length of the alignment. Near Lake Houston, several residential subdivisions or planned residential areas would be traversed. The bermed and elevated pipeline section would cause a linear, unbroken visual and aesthetic barrier (negatively impacting the area) to the existing and future planned communities. | Direct impacts from Alternative 6 include the disruption of the view shed from project elements such as the maintenance facility and any elevated structures; change in use of pastureland or agricultural land; and the removal of vegetation along the project view shed. The proposed, fenced pipeline easement with access road and associated facilities would cross through agricultural fields, industrial and residential areas for much of the length of the alignment. Near Lake Houston, several residential subdivisions or planned residential areas would be traversed. The bermed and elevated pipeline section would cause a linear, unbroken visual and aesthetic barrier (negatively impacting the area) to the existing and future planned communities. | No |
| **Human Noise-Sensitive Receptors** | Under this alternative, the existing noise environment would remain consistent with baseline conditions. | Construction noise would occur and would be localized. According the *Capers Ridge Noise study*, areas that currently beyond 300 feet experience a noise level that would be no louder than existing noise background levels. | Construction noise would occur and would be localized. According the *Capers Ridge Noise study*, areas that currently beyond 300 feet experience a noise level that would be no louder than existing noise background levels. | Construction noise would occur and would be localized. According the *Capers Ridge Noise study*, areas that currently beyond 300 feet experience a noise level that would be no louder than existing noise background levels | No |
| **Ecological Noise-Sensitive Receptors** | Under this alternative, the existing noise environment would remain the same. | Construction noise would occur and would be localized. According the noise study, areas that currently beyond 300 feet noise would 50db, which is no louder than existing noise background levels. | Construction noise would occur and would be localized. According the noise study, areas that currently beyond 300 feet noise would 50db, which is no louder than existing noise background levels | Construction noise would occur and would be localized. According the noise study, areas that currently beyond 300 feet noise would 50db, which is no louder than existing noise background levels | No |
| **Food and Fiber Production** | Under the No Action alternative, food and fiber production would be consistent with regional and local trends similar to baseline conditions. | No direct or permanent impacts to the road and infrastructure network are anticipated as a result of construction, operation, or maintenance associated with Alternative 3A. The proposed canal would flow underground at roadway crossings. Fencing would be constructed to prevent vehicle and pedestrian access at roadway and other infrastructure crossings. | No direct or permanent impacts to the road and infrastructure network are anticipated as a result of construction, operation, or maintenance associated with Alternative 4. The proposed canal would flow underground at roadway crossings. Fencing would be constructed to prevent vehicle and pedestrian access at roadway and other infrastructure crossings. | No direct or permanent impacts to the road and infrastructure network are anticipated as a result of construction, operation, or maintenance associated with Alternative 6. The proposed canal would flow underground at roadway crossings. Fencing would be constructed to prevent vehicle and pedestrian access at roadway and other infrastructure crossings. | No |
| **Recreation and Navigation including Boating:** The 3,000 acre property proposed for mitigation for the LBITP was acquired by the Applicant in 2010. Since that time, no hunting has been allowed on that property along the lower Trinity River. | The No Action Alternative would result in no effect on recreation and navigation compared to baseline conditions with the exception that Lake Houston water levels would be expected to be lower than current conditions due to the need to obtain as much surface water for supplies as possible thus affecting boating and fishing. | A limited, local effect in the area of intake pump construction would occur on recreation and non-commercial navigation, including boating, would occur with Alternative 3A. It is anticipated that Lake Houston water levels would remain consistent with baseline conditions in accordance with operating procedures. | A limited, local effect in the area of intake pump construction would occur on recreation and non-commercial navigation, including boating, would occur with Alternative 4. It is anticipated that Lake Houston water levels would remain consistent with baseline conditions in accordance with operating procedures. | A limited, local effect in the area of intake pump construction would occur on recreation and non-commercial navigation, including boating, would occur with Alternative 6. It is anticipated that Lake Houston water levels would remain consistent with baseline conditions in accordance with operating procedures. | No |

| Resource – Existing Condition/Current Health | Alternative 1<br>No Action | Alternative 3A<br>Direct Effects and Significance | Alternative 4<br>Direct Effects and Significance | Alternative 6<br>Direct Effects and Significance | Resource Carried Forward for CEA Analysis? |
|---|---|---|---|---|---|
| **Safety and Security**<br>Expose people, structures, or population to safety or security risks or adverse effects from use of surface water source of water supply to Houston ETJ. | No changes to safety or security risks would be expected as result of the No Action Alternative | Security measures along the canal and LBITP Alternative 3A ROW are under evaluation. At present, the preliminary LBITP design incorporates the use of a 4-strand barb wire fence along the entire LBITP ROW alignment except at major roadway and pipeline or utility easement crossings. In these locations, a 6-foot chain-link fence may be used to deter trespass and address safety and security concerns in areas with available public access such as at roadway crossings.<br><br>In terms of citizen safety, installation of fencing surrounding the LBITP canal would be necessary to prevent accidental, water-related injuries from occurring. In areas of frequent public access, such as at the proposed mitigation property that would become part of the Trinity River National Wildlife Refuge (TRNWR), Security concerns would be addressed in accordance with EPA and DHS provisions for public drinking water safety. | Security measures along the canal and LBITP Alternative 4 ROW are still under evaluation.<br><br>In terms of citizen safety, installation of fencing surrounding the LBITP canal would be necessary to prevent accidental, water-related injuries from occurring. In areas of frequent public access, such as at the proposed mitigation property that would become part of the Trinity River National Wildlife Refuge (TRNWR). Security concerns would be addressed in accordance with EPA and DHS provisions for public drinking water safety. | Security measures along the canal and LBITP Alternative 6 ROW are still under evaluation.<br><br>In terms of citizen safety, installation of fencing surrounding the LBITP canal would be necessary to prevent accidental, water-related injuries from occurring. In areas of frequent public access, such as at the proposed mitigation property that would become part of the Trinity River National Wildlife Refuge (TRNWR). Security concerns would be addressed in accordance with EPA and DHS provisions for public drinking water safety. | No. With the heightened terrorist threat in the United States, it is important to manage security concerns associated with the LBITP water transfer to Lake Houston, a Houston metropolitan area drinking water supply source. Contamination through biological agents would be a concern in open water situations such as canals or channels. At roadway and other crossings, the raw water from the Trinity River could be contaminated and source water protection would be addressed to control threats to public safety related to source water protection requirements as implemented by the EPA. In terms of citizen safety, installation of fencing surrounding the LBITP canal would be necessary to prevent accidental, water-related injuries from occurring. Security measures for the LBITP per EPA and Department of Homeland Security (DHS) requirements would need to be implemented |
| **Energy and Mineral Resources** | The No Action Alternative would result in no effect on Energy and Mineral resources compared to baseline conditions | One Natural Gas Pipeline (NGPL) Interconnect Meter Site Crossing was identified near the Stoesser property. No electrical power corridors were identified within the ROW of the proposed Alternative 3A and no oil wells are located in the proposed Alternative 3A footprint, although there is a dry hole present in the vicinity of the sedimentation basin. No other energy or mineral resources were identified within the proposed project ROW. | Approximately 19 electrical power corridors were identified as crossing the ROW of proposed Alternative 4. | Approximately 10 electrical power corridors were identified as crossing the ROW of proposed Alternative 6. | No |
| **Health and General Welfare of the People** | The No Action Alternative would not contribute to the health and general welfare of the people. | Alternative 3A would contribute to the health and general welfare of the people as a sufficient, sustainable, low-cost, high-quality and long-term source of water supply is used from available water rights under permit by the TCEQ. However, there is the potential that this project would result in the transfer of zebra mussels, an invasive species, from one watershed to another. | Alternative 4 would contribute to the health and general welfare of the people as a sufficient, sustainable, low-cost, high-quality and long-term source of water supply is used from available water rights under permit by the TCEQ. However, there is the potential that this project would result in the transfer of zebra mussels, an invasive species, from one watershed to another. | Alternative 6 would contribute to the health and general welfare of the people as a sufficient, sustainable, low-cost, high-quality and long-term source of water supply is used from available water rights under permit by the TCEQ. However, there is the potential that this project would result in the transfer of zebra mussels, an invasive species, from one watershed to another. | No |
| **Ecology and Biodiversity** | The No Action Alternative would result in no change to this resource. | Permanent, long-term, and adverse affects of approximately 1,105 acres of property as a result of the implementation of Alternative 3A. The proposed Alternative 3A canal, and associated water supply security fencing or controls, could create a barrier to the mobility of mammal species present in the project area causing permanent isolation of populations and reduced genetic variability. | Permanent, long-term, and adverse affects of approximately 985 acres of property as a result of the implementation of Alternative 4. The proposed Alternative 4 fenced, linear pipeline easement, and associated water supply security fencing or controls, could create a barrier to the mobility of mammal species present in the project area causing permanent isolation of populations and reduced genetic variability. | Permanent, long-term, and adverse affects of approximately 700 acres of property as a result of the implementation of Alternative 6. The proposed Alternative 6 fenced, linear pipeline easement, and associated water supply security fencing or controls, could create a barrier to the mobility of mammal species present in the project area causing permanent isolation of populations and reduced genetic variability. | **Yes,** considered to be assessed during the wetlands and waters of the United States analyses. |
| **Uplands and Upland Habitat** *(not specified in DEIS)* | The No Action Alternative would result in no change to this resource. | Approximately 957 acres of uplands and upland habitat would be affected by the proposed LBITP. | Approximately 866 acres of uplands and upland habitat would be affected by the proposed LBITP. | Approximately 688 acres of uplands and upland habitat would be affected by the proposed LBITP. | No |

| Resource – Existing Condition/Current Health | Alternative 1<br>No Action | Alternative 3A<br>Direct Effects and Significance | Alternative 4<br>Direct Effects and Significance | Alternative 6<br>Direct Effects and Significance | Resource Carried Forward for CEA Analysis? |
|---|---|---|---|---|---|
| **Bottomlands and Bottomland Habitat** | The No Action Alternative would result in no change to this resource. | There would be significant, direct, long-term effect on bottomlands and bottomland habitat present along the lower Trinity River, Luce Bayou, and Lake Houston as a result of the implementation of the LBITP. Bottomland impacts total 1.5 acres. | There would be significant, direct, long-term effect on bottomlands and bottomland habitat present along the lower Trinity River and Lake Houston as a result of the implementation of the LBITP. Cedar Bayou would also be directly impacted by the proposed installation of the Alternative 4 pipeline through the Cedar Bayou watershed and floodplains. Bottomland impacts total 3.9 acres. | There would be significant, direct, long-term effect on bottomlands and bottomland habitat present along the lower Trinity River and Lake Houston as a result of the implementation of the LBITP. Cedar Bayou would also be directly impacted by the proposed installation of the Alternative 6 pipeline through the Cedar Bayou watershed and floodplain. Bottomland impacts total 11.3 acres. | **Yes,** considered to be assessed during the wetlands and waters of the United States analyses. |
| **Aquatic Resources (Species)**<br>*(see Fishes resource below)* | The No Action Alternative would result in no change to this resource. | | | | |
| **Waters of the United States, including Wetlands** | The No Action Alternative would result in no change to this resource. | Approximately 203 acres would be permanently impacted; no stream crossings | Approximately 65 acres would be permanently impacted; 38 stream crossings | | **Yes evaluated through the analyses conducted for the waters of the United States, including wetlands RSA** |
| **Riparian Habitat** | The No Action Alternative would result in no anticipated changes to riparian habitat caused by No Action. | There would be significant, direct, long-term effect on riparian habitat present along the lower Trinity River, Luce Bayou, and Lake Houston as a result of the implementation of the LBITP. Perennial and intermittent streams would be affected for a distance of 19,873 linear feet along the proposed alternative alignment. Approximately 4.9 acres of open water resources would be directly affected. Bottomland impacts total 1.5 acres. Vegetation types important for wetlands functioning and protection are present within 198.8 acres along the proposed ROW. | There would be significant, direct, long-term effect on riparian habitat present along the lower Trinity River, and Lake Houston as a result of the implementation of the LBITP. Cedar Bayou would also be directly impacted by the proposed installation of the Alternative 4 pipeline through the Cedar Bayou watershed and floodplain. Perennial and intermittent streams would be affected for a distance of 20,471 linear feet along the proposed alternative alignment. Approximately 4.5 acres of open water resources would be directly affected. Bottomland impacts total 3.9 acres. Vegetation types important for wetlands functioning and protection are present within 219.3 acres along the proposed ROW. | There would be significant, direct, long-term effect on riparian habitat present along the lower Trinity River, and Lake Houston as a result of the implementation of the LBITP. Cedar Bayou would also be directly impacted by the proposed installation of the Alternative 6 pipeline through the Cedar Bayou watershed and floodplain. Perennial and intermittent streams would be affected for a distance of 15,794 linear feet along the proposed alternative alignment. Approximately 0.9 acres of open water resources would be directly affected. Bottomland impacts total 11.3 acres. Vegetation types important for wetlands functioning and protection are present within 144.9 acres along the proposed ROW. | **Yes—evaluated through the analyses conducted for the waters of the United States, including wetlands RSA** |
| **Fishes** | The No Action Alternative would result in no change to this resource. | Pumping could impinge larger fish on intake screens, and entrain fish eggs and mussel larvae through the transfer system. The proposed project would utilize a trash rack and screening that would impact aquatic species that could potentially get caught and trapped. | Pumping could impinge larger fish on intake screens, and entrain fish eggs and mussel larvae through the transfer system. The proposed project would utilize a trash rack and screening that would impact aquatic species that could potentially get caught and trapped. | Pumping could impinge larger fish on intake screens, and entrain fish eggs and mussel larvae through the transfer system. The proposed project would utilize a trash rack and screening that would impact aquatic species that could potentially get caught and trapped. | No. |
| **Rare, Threatened, Endangered or Protected Species** | The No Action Alternative would result in no change to this resource. | Three threatened and endangered reptile and amphibian species that could potentially be impacted by the construction, operation, and maintenance activities associated with the proposed action alternatives including the alligator snapping turtle, northern scarlet snake, and timber/canebrake rattlesnake. | Three threatened and endangered reptile and amphibian species that could potentially be impacted by the construction, operation, and maintenance activities associated with the proposed action alternatives including the alligator snapping turtle, northern scarlet snake, and timber/canebrake rattlesnake. | Three threatened and endangered reptile and amphibian species that could potentially be impacted by the construction, operation, and maintenance activities associated with the proposed action alternatives including the alligator snapping turtle, northern scarlet snake, and timber/canebrake rattlesnake. | **Yes--evaluated through the analyses conducted for wildlife and vegetation RSA** |
| **Migratory and Resident Bird Species** | The No Action Alternative would result in no change to this resource (see Habitat and Habit Values below). | Temporary effects to wildlife habitat that would result from the proposed action alternatives include the decreased attractiveness of habitat adjacent to the project corridor, as well as possible disturbances to normal behavior patterns of wildlife as a result of increased noise levels from construction activities. | Temporary effects to wildlife habitat that would result from the proposed action alternatives include the decreased attractiveness of habitat adjacent to the project corridor, as well as possible disturbances to normal behavior patterns of wildlife as a result of increased noise levels from construction activities. | Temporary effects to wildlife habitat that would result from the proposed action alternatives include the decreased attractiveness of habitat adjacent to the project corridor, as well as possible disturbances to normal behavior patterns of wildlife as a result of increased noise levels from construction activities. | No |

| Resource – Existing Condition/Current Health | Alternative 1<br>No Action | Alternative 3A<br>Direct Effects and Significance | Alternative 4<br>Direct Effects and Significance | Alternative 6<br>Direct Effects and Significance | Resource Carried Forward for CEA Analysis? |
|---|---|---|---|---|---|
| **Wildlife Habitat and Habitat Values** | The No Action Alternative would result in no change to this resource. | Temporary effects to wildlife habitat that would result from the proposed action alternatives include the decreased attractiveness of habitat adjacent to the project corridor, as well as possible disturbances to normal behavior patterns of wildlife as a result of increased noise levels from construction activities.<br><br>Alternative 3A would result in direct, short-term impacts on wildlife habitat, including habitat loss through its conversion to surface water conveyance infrastructure and maintained ROW. | Temporary effects to wildlife habitat that would result from the proposed action alternatives include the decreased attractiveness of habitat adjacent to the project corridor, as well as possible disturbances to normal behavior patterns of wildlife as a result of increased noise levels from construction activities. Alternative 4 would result in direct, short-term impacts on wildlife habitat, including habitat loss through its conversion to surface water conveyance infrastructure and maintained ROW. | Temporary effects to wildlife habitat that would result from the proposed action alternatives include the decreased attractiveness of habitat adjacent to the project corridor, as well as possible disturbances to normal behavior patterns of wildlife as a result of increased noise levels from construction activities. Alternative 6 would result in direct, short-term impacts on wildlife habitat, including habitat loss through its conversion to surface water conveyance infrastructure and maintained ROW. | **Yes--evaluated through the analyses conducted for wildlife and vegetation RSA** |
| **Non-Native and Invasive Species** (Identified in DEIS as "Nuisance, Exotic and Invasive Species"). | The No Action Alternative would result in no change to this resource. | Although mitigation and monitoring re Zebra Mussel Control Plan would occur during LBITP implementation, it is possible that zebra mussels would be transferred from Trinity River to Lake Houston as a result of the LBITP if the mussel is present in the lower Trinity River and not in the San Jacinto River watershed. . | Although mitigation and monitoring re Zebra Mussel Control Plan would occur during LBITP implementation, it is possible that zebra mussels would be transferred from Trinity River to Lake Houston as a result of the LBITP if the mussel is present in the lower Trinity River and not in the San Jacinto River watershed. . | Although mitigation and monitoring re Zebra Mussel Control Plan would occur during LBITP implementation, it is possible that zebra mussels would be transferred from Trinity River to Lake Houston as a result of the LBITP if the mussel is present in the lower Trinity River and not in the San Jacinto River watershed. . | **Yes--evaluated through the analyses conducted for wildlife and vegetation RSA** |
| **Nuisance and Noxious Species** – *see above* | The No Action Alternative would result in no change to this resource other than what would occur under natural conditions of species migration. | See above | See above | See above | See above |
| **Environmental Flows** | The No Action Alternative would result in no change to environmental flows. | There could be a reduction of up to 7 percent of the flow of the lower Trinity River with the implementation of the LBITP. Resultant effects on environmental flows, although well-studied, are still not well understood. Environmental flows would still reach Galveston Bay, although through the San Jacinto River watershed rather than from the Lower Trinity River to Trinity Bay and then to Galveston Bay. | There could be a reduction of up to 7 percent of the flow of the lower Trinity River with the implementation of the LBITP. Resultant effects on environmental flows, although well-studied, are still not well understood. Environmental flows would still reach Galveston Bay, although through the San Jacinto River watershed rather than from the Lower Trinity River to Trinity Bay and then to Galveston Bay | There could be a reduction of up to 7 percent of the flow of the lower Trinity River with the implementation of the LBITP. Resultant effects on environmental flows, although well-studied, are still not well understood. Environmental flows would still reach Galveston Bay, although through the San Jacinto River watershed rather than from the Lower Trinity River to Trinity Bay and then to Galveston Bay | No |
| **Instream Flows** | The No Action Alternative would result in no change to this resource. | Modeling instream flow effects of the LBITP was conducted by AECOM (2/1/10, see Appendix M). Based on the proposed diversion schedule, on an annual basis, approximately 7 percent apparent reduction in inflows would occur at a location further downstream of the Romayor gauge. Increased Lake Livingston releases would occur to meet LBITP demands and this increase may increase streamflow possibly as far downstream as the existing TRPS. It is also possibly that instream flows in the Trinity River may increase from Lake Livingston releases during dry periods of the year, but this effect may occur on an annualized basis. The LBITP would also result in a reduction of peak flows that occur within the Trinity River. | Modeling instream flow effects of the LBITP was conducted by AECOM (2/1/10, see Appendix X). Based on the proposed diversion schedule, on an annual basis, approximately 7 percent apparent reduction in inflows would occur at a location further downstream of the Romayor gauge. Increased Lake Livingston releases would occur to meet LBITP demands and this increase may increase streamflow possibly as far downstream as the existing TRPS. It is also possibly that instream flows in the Trinity River may increase from Lake Livingston releases during dry periods of the year, but this effect may occur on an annualized basis. The LBITP would also result in a reduction of peak flows that occur within the Trinity River. | Modeling instream flow effects of the LBITP was conducted by AECOM (2/1/10, see Appendix X). Based on the proposed diversion schedule, on an annual basis, approximately 7 percent apparent reduction in inflows would occur at a location further downstream of the Romayor gauge. Increased Lake Livingston releases would occur to meet LBITP demands and this increase may increase streamflow possibly as far downstream as the existing TRPS. It is also possibly that instream flows in the Trinity River may increase from Lake Livingston releases during dry periods of the year, but this effect may occur on an annualized basis. The LBITP would also result in a reduction of peak flows that occur within the Trinity River. | No |

| Resource – Existing Condition/Current Health | Alternative 1<br>No Action | Alternative 3A<br>Direct Effects and Significance | Alternative 4<br>Direct Effects and Significance | Alternative 6<br>Direct Effects and Significance | Resource Carried Forward for CEA Analysis? |
|---|---|---|---|---|---|
| **Ecosystems and Fragmentation** *(see ecology and biodiversity above)* | The No Action Alternative would result in no change to this resource. | Permanent, long-term, and adverse affects of approximately 1,105 acres of property as a result of the implementation of Alternative 3A. The proposed Alternative 3A canal, and associated water supply security fencing or controls, could create a barrier to the mobility of mammal species present in the project area causing permanent isolation of populations and reduced genetic variability. | Permanent, long-term, and adverse affects of approximately 985 acres of property as a result of the implementation of Alternative 4. The proposed Alternative 4 fenced, linear pipeline easement, and associated water supply security fencing or controls, could create a barrier to the mobility of mammal species present in the project area causing permanent isolation of populations and reduced genetic variability. | Permanent, long-term, and adverse affects of approximately 700 acres of property as a result of the implementation of Alternative 6. The proposed Alternative 6 fenced, linear pipeline easement, and associated water supply security fencing or controls, could create a barrier to the mobility of mammal species present in the project area causing permanent isolation of populations and reduced genetic variability. | Yes, evaluated through the analyses conducted for wildlife and vegetation RSA |
| **Managed and/or Protected Areas** | The No Action Alternative would result in no change to this resource. | The implementation of Alternative 3A would result in approximately 3,000 acres of property transferred to the Trinity River National Wildlife Refuge as part of the planned LBITP mitigation. | The implementation of Alternative 4 would result in approximately 3,000 acres of property transferred to the Trinity River National Wildlife Refuge as part of the planned LBITP mitigation. | The implementation of Alternative 6 would result in approximately 3,000 acres of property transferred to the Trinity River National Wildlife Refuge as part of the planned LBITP mitigation. | No |
| **Estuarine Environment and Mud Flats/Bay Bottom** | The No Action Alternative would result in no change to this resource. | Alternative 3A would indirectly affect the Galveston Bay (Trinity Bay) estuarine environment and mud flats/bay bottom as environmental flows are altered through project implementation—water transferred from the lower Trinity River to Lake Houston would enter Galveston Bay via the Galveston-San Jacinto River watershed. Increased return flows from Region C would also cause an increase in environmental flow to to enter into Galveston Bay through the Galveston-San Jacinto River watershed. | Alternative 4 would indirectly affect the Galveston Bay (Trinity Bay) estuarine environment and mud flats/bay bottom as environmental flows are altered through project implementation—water transferred from the lower Trinity River to Lake Houston would enter Galveston Bay via the Galveston-San Jacinto River watershed. Increased return flows from Region C would also cause an increase in environmental flow to to enter into Galveston Bay through the Galveston-San Jacinto River watershed. | Alternative 6 would indirectly affect the Galveston Bay (Trinity Bay) estuarine environment and mud flats/bay bottom as environmental flows are altered through project implementation—water transferred from the lower Trinity River to Lake Houston would enter Galveston Bay via the Galveston-San Jacinto River watershed. Increased return flows from Region C would also cause an increase in environmental flow to to enter into Galveston Bay through the Galveston-San Jacinto River watershed. | No |
| **Submerged Aquatic Vegetation (SAV)** | The No Action Alternative would result in no change to this resource. | SAV is not present within the direct or indirect area that would affected by the proposed alternative and therefore no effects are anticipated. | SAV is not present within the direct or indirect area that would affected by the proposed alternative and therefore no effects are anticipated. | SAV is not present within the direct or indirect area that would affected by the proposed alternative and therefore no effects are anticipated. | No |
| **Beaches and Dunes** | The No Action Alternative would result in no change to this resource. | Beaches and dunes are not present within the direct or indirect area that would affected by the proposed alternative and therefore no effects are anticipated. | Beaches and dunes are not present within the direct or indirect area that would affected by the proposed alternative and therefore no effects are anticipated. | Beaches and dunes are not present within the direct or indirect area that would affected by the proposed alternative and therefore no effects are anticipated. | No |

### 5.1.4 Step 4: Identify the Project's Direct and Indirect Impacts

This step identifies the direct and indirect impacts that could result from the project that may contribute to a cumulative effect when added to non-project related effects. Direct and indirect impacts are defined by CEQ regulations (40 CFR 1508.8) as follows:

> *Direct impacts are caused by the action and occur at the same time and place* (40 CFR 1508.8)
>
> *Indirect (secondary) impacts are caused by the action and are later in time and farther removed in distance, but are still reasonably foreseeable. Indirect impacts may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate and related effects on air and water and other natural systems, including ecosystems* (40 CFR 1508.8)

### 5.1.5 Step 5: Identify Other Reasonable Foreseeable Effects

An indirect impact and CEA must consider past, present and reasonably foreseeable future actions. Observing development trends helps determine the types of development projects that have caused the current health of the land and other resources, and the trends the resources are experiencing. Looking to the past and present also provides insight about the effect future development may have on resource trends.

According to U.S. Department of Transportation (USDOT) (2005), *Factors that indicate that an action or project is reasonably foreseeable for the purposes of cumulative effects analysis…* include:

a. Whether the project has been Federally approved

b. Whether there is funding pending before agency for the project

c. Whether there is evidence of active preparation to make a decision on alternatives to the project

A reasonably foreseeable private-sector project could be one for which land has been acquired and is awaiting favorable market conditions to develop. Municipalities often conduct long-term planning studies to determine locations for new or upgraded schools, roadways, developments, and project water supply needs.

Cumulative effects analyses guidance states it is unreasonable and impractical to identify and discuss every project built in the RSA (TxDOT 2007 and National Cooperative Highway Research Program [NCHRP] 466). It is advisable to specify projects that have occurred, and changes to the resource resulted from those projects. The same guidance urges caution in determining reasonably foreseeable projects based on local and state planning initiatives.

> *While a general plan is an excellent starting point to identify reasonable foreseeable local development projects, it may be necessary to consult other sources and experts to refine the cumulative impact assessment. Not all projects presented in a general plan or master plan may be constructed, and including all of the projects identified in these plans could cause the cumulative impact analysis to overestimate the potential cumulative impacts of local development. On the other hand, there may be projects that are not included in the general plan (particularly if it has not been updated recently) that, if left out of the analysis, might underestimate cumulative impacts* (TxDOT 2007)

The TxDOT guidance also notes underestimating would also occur if viable projects in their infancy are not included in the analysis. Contrary to the transparency and extended length of public project planning, private development can move comparatively fast, and is often invisible to regulatory agencies and the public until relatively close to the ground-breaking date. Nevertheless, sections discussing reasonably foreseeable effects are included in the analysis.

As previously stated, the mid-1970s has been selected as the baseline year for this CEA. Historical quantitative and geographically referenced (mapped) information on the various resources (e.g., acres of a given resource, land use, or land cover type) for prior years are available based on past studies and mapping conducted for the Texas Coastal Zone, although a complete list of past actions may not be readily available. CEQ NEPA regulations and guidance on cumulative effects do not require developing a catalog with specific past actions or quantifying these actions in a CEA. CEQ recognizes this may not be practical, and information may not be available (40 CFR 1500-1508 and CEQ 2005). It is naturally accepted past projects have occurred.

**Table 5-2** provides a list of past, present and reasonably foreseeable projects that are included in the LBITP cumulative effects analysis presented herein. **Figure 5-1** provides information related to the boundaries of Region H in the Houston and project area as well as watersheds and pertinent water supply projects in the area.

### 5.1.6 Step 6: Identify and Assess Cumulative Impacts

The goal of the CEA is to quantitatively assess the cumulative effects on resource health and trends in the RSA. However, incomplete or unavailable information precluded a quantitative assessment for all resources. In these cases, a qualitative assessment for the cumulative effect on each resource within the larger RSA was provided. The CEA considered the project's direct and indirect impacts along with the effects from past, present and reasonably foreseeable future projects. The cumulative effect's magnitude was determined by comparing the effect to the health and trend of the affected resource.

### 5.1.7 Step 7: Report the Results

The CEA results are reported as Step 7. Direct and indirect impacts were summarized in this section as they are included in the CEA. The assumptions and methods used are described in the appropriate resource sections.

In some cases such as waters of the United States, including wetlands, and floodplains, the CEA may overstate effects. Including resource features within a geographically defined development area does not imply all such resources would be adversely affected. Actual impacts to some of these resources could potentially be reduced, as federal and state regulations and local ordinances regulate development affecting these resources. In other cases, such as historic and archeological resources, regulating development applies only to projects requiring federal monies or permits, and these regulations mandate considering, not protecting the resource. Other resources such as farmlands, vegetative or wildlife habitat, and open space are not effectively regulated for either public or private development. The cumulative effects to resources presented in this section represent the anticipated development forecasted through 2040 based on Region H RWP and information available based on research conducted.

### 5.1.8 Step 8: Assess the Need for Mitigation

Opportunities for mitigating adverse effects are discussed for each resource. These are not meant to be mitigation measures the USACE would, or has the authority to, implement. Rather, they are intended to disclose steps or actions which could potentially be undertaken by local, state and federal agencies and organizations to minimize the potential cumulative effect on each resource's health and trend.

## 5.2 Applying the 8-Step Process

Direct and indirect impacts of the No Action Alternative and Alternatives 3A, 4, and 6 are summarized in **Table 5-1**. Each resource category was reviewed for indirect and direct impacts and then assessed for cumulative effects. The candidate resources for investigation include economics; waters of the United States, including wetlands, floodplains, and hydrology; wildlife and vegetation; and prime farmlands and prime farmland soils. **Table 5-1** summarizes the potential issues, direct effects analyses, for the resources and issues per alternative evaluated in this DEIS. This table summarizes the potential direct effects of the project Alternatives 3A, 4, and 6; identifies which resources are carried forward and evaluated in this CEA; and identifies why some resources were eliminated from the cumulative effects evaluation.

After review of the resource health and potential impacts of the proposed project, resources identified for analysis in this CEA include: economics; waters of the United States, including wetlands, floodplains, and hydrology; wildlife and vegetation; and prime farmland and prime farmland soils. Floodplains, hydrology, and waters of the United States, including wetlands are evaluated together since the indirect and direct effects as well as cumulative effects are interdependent and this interrelationship causes difficulty in assessing these resources separately in a way that allows the public and permit decision-maker to understand the direct, indirect, and cumulative effects. Five resource study areas (RSAs) were identified in order to evaluate the candidate resources for Alternatives 3A, 4 and 6 and the anticipated projects to be included in the cumulative effects analysis (CEA) within these RSAs as summarized by **Table 5-2**.

### 5.2.1 Socioeconomic Resources: Economics

This section presents the CEA for the LBITP on economic resources as described through alternative-specific analyses and analyses provided for the LBITP (a proposed water management strategy) that was included in the 2011 Region H Regional Water Plan (RWP). This discussion addresses compliance with Region H and state water planning efforts as they relate to the LBITP. Economic impacts from the LBITP have been evaluated by TWDB during the implementation of the state's regional water planning process. Additional studies have also been conducted to evaluate on an alternative basis the economic effects of project implementation.

#### 5.2.1.1 Resource Study Area (RSA) for Alternatives 3A, 4 and 6: Economics

The RSA for cumulative effects analysis for the economics is identified as the LBITP water supply area, generally the Region H boundary established by the TWDB (**Figure 5-1**). Participating LBITP third parties include the Houston, North Harris County Regional Water Authority (NHCRWA), West Harris County Regional Water Authority (WHCRWA), Central Harris County Regional Water Authority (CHCRWA), and North Fort Bend Water Authority (NFBWA).

#### 5.2.1.2 Current Health and Historical Context Summary

The Applicant is a Conservation and Reclamation District established by the Texas Legislature in 1967 with a Board appointed by the Governor of Texas and the City of Houston. The Applicant is implementing the LBITP, a regional water supply project which would transfer raw water from the Trinity River Basin to Lake Houston, which is a major Houston water supply reservoir. In some form, the proposed project has been an integral part of Texas water planning for at least the past 50 years. The project would ultimately convey approximately 450 million gallons per day (MGD) of untreated or raw water by underground pipeline and aboveground canal for treatment and distribution to City of Houston water customers. The proposed project is a long-planned water supply project which is critical to meeting projected growth and increased water demands vital to sustaining the long-term economic health for the Houston metropolitan area and surrounding communities. LBITP is needed to meet the projected water demand in the Houston metropolitan area and to increase available water supplies to comply with contracted, future demands identified by Houston.

**Table 5-2:**
**Projects Identified for Cumulative Effects Analysis (CEA)**

| Project | Description (purpose, scope, known issues) | Status | Reason for Dismissal |
|---|---|---|---|
| KeystoneXL Pipeline, Gulf Coast Project | The regional scale of the proposed Trans-Canada pipeline (aka KeystoneXL Project) is significant. The 47-mile Houston lateral pipeline project is under construction and extends north-south through Liberty County to transport oil to refineries in the Houston area along the Houston Ship Channel (HSC). These are critical infrastructure projects for the energy security of the United States and the American economy. The Gulf Coast Project and Houston Lateral Project will transmit production to refineries. **Known issues**: Construction related short-term effects for fugitive dust emissions, oil and gas well re-locations, direct construction impacts from pipeline installation including highly erodible soils, agricultural lands and rangeland lost to construction ROW; short-term local increases in TSS and sediment to perennial streams and rivers; disturbance of native and low quality uplands, forests and agricultural/cropland, wetlands and upland habitats cleared for pipeline construction; wildlife displacements and potential reduction of sensitive species habitats, potential impacts to cultural resources; acquisition of easements and fee property from land owners for pipeline ROW; direct employment to workers and demands on local infrastructure for the construction period; increased state revenues due to property taxes; potential for release of crude oil and resulting impacts to groundwater and ecologically sensitive habitat. | Licensed by FERC for Gulf Coast Project. Section 404 DA permit issued by U.S. Corps of Engineers on July 27, 2012. Construction of Houston Lateral Project was initiated in August 2012 and scheduled for completion mid- to late-2013. At a minimum 700,000 barrels of oil per day can be transported to Gulf Coast refineries upon completion. | Retained |
| Lake Livingston Hydroelectric Project | The 24-megawatt (MW) project would generate approximately 124,000 megawatt-hours (mWh) of energy annually through water releases needed to maintain a 131 feet msl pool elevation that would otherwise spill over the dam due to high water levels that may occur during flood stage. **Known issues**: Effects of the operation on water quality (DO, turbidity, and temperature) and fisheries resources (entrainment, impingement) downstream of the Lake Livingston dam as well as access to public recreation. Dredging would occur within a 250-foot long open channel, extending approximately 1,000 feet downstream of the spillway (excavation of 1,000,000 cubic yards of soils and 50,000 cubic years of sediments). Construction would also occur within the Trinity River for a distance of 250 linear feet. Potential effects to aquatic resources would be limited to the direct area of construction. Potential downstream transfers of aquatic invasive species present in the upper Trinity River watershed to the lower Trinity River. | Licensed by FERC; construction phase to occur in 2013 through 2015 | De minimis and therefore dismissed. |
| ENSTOR Houston HUB Storage and Transportation Facility, LP | A high-deliverability natural gas storage facility designed for injection, storage, and withdrawal of natural gas from salt caverns to be created in the North Dayton Salt Dome. **Known issues**: Proximity of the LBITP canal and pipeline alignments of Alternatives 3A and 4 to the NGPL metering transfer station; easement and property from productive agricultural and prime farmland land; construction related short-term effects for fugitive dust emissions, oil and gas well re-locations, direct construction impacts from project installation; short-term local increases in TSS and sediment to perennial streams and rivers; land and habitat disturbance; use of water for operations, potential sinkhole generation as dome is expanded for storage, potential contamination related to operation of equipment and facilities; increased state revenues. | Licensed by FERC, will move to the construction and operation phase pending economic conditions and customer needs. | Retained |

| Project | Description (purpose, scope, known issues) | Status | Reason for Dismissal |
|---|---|---|---|
| Allen's Creek Reservoir | The proposed water supply reservoir will cover 7,000 acres and be located immediately upstream of the confluence of Allen's Creek and the Brazos River. Diversion of water and provision of supply from Allen's Creek limited to water that is in excess of downstream, senior water rights. **Known issues**: Significant change to land use and habitat as area changes to a constructed reservoir, environmental flows to bays and estuaries, instream flows to Brazos River, identified rare species in Austin County, Texas that may be potentially affected by the proposed reservoir construction and filling in addition to wetlands, floodplains, and aquatic resources. | Included in Region H Water Plan; property purchased by Houston in approximately 2000, environmental studies may start as early as 2011 or 2012. Design phase starting in 2013 and constructed anticipated between 2018 and 2020. | Dismissed; not within the geographic boundary of the identified RSAs or reasonably foreseeable since project permits are needed. |
| CWA Trinity River Pump Station (TRPS) Expansion | CWA is the owner and operator of the TRPS, which is situated on an approximately 62 acre tract located on the Trinity River approximately 6.7 miles south of Liberty, Texas. The facilities consist of a side-channel intake structure with trash racks, pump station, discharge piping, outfall structure, sedimentation basin, flume, canal, sediment storage site, electrical substation, shop building, control building, dredge storage building, water well, package sanitation system, a residential home, and access road. Water passes through trash racks to remove debris, is then directed to the sedimentation basin, and then discharges through the flume before entering the Main Canal. The raw water intake and pump station was expanded from 12 pump bays used for housing vertical turbine pumps (VTPs) to 18 pump bays in 2008. Currently, 16 VTPs occupy the pump bays leaving two open for future expansion. With the recent expansion, the existing firm capacity of the TRPS is approximately 1 billion gallons per day (BGD) and the total capacity is 1.3 BGD using all 16 pumps. **Known issues**: The TRPS adjoins Trinity River NWR property and large-scale water withdrawals may affect the river banks and sediments (point bars) of property owned by the USFWS; changes to sediment movement associated with increased water pumping; water quality, and stream bank stabilization along the lower Trinity River related to water removal; increased water and sediment withdrawal and subsequent change to flow, geomorphology, and potential for erosion; potential transfer of invasive aquatic species from Trinity River watershed to San Jacinto River watershed; and finally, instream Trinity River flows and Galveston Bay and estuary flows. | Constructed in 2008 | Retained |
| Grand Parkway SH 99, Segment H and I-1 (and I-69) | Constructed through Liberty County crossing project area. I-69, Trans-Texas Corridor, has also been implemented and parallels the SH 99. **Known issues**: I-69 would likely impact wetlands, but no quantitative numbers have been generated since a route has not been identified. Segments H and I-1 could impact direct impacts to aquatic resources ranging from 7.3 to 18.9 acres depending on the alternative alignment selected. Proposed roadway project could also induce direct, indirect, and secondary population and development growth in areas currently easily accessible which would result in land use change and incremental effects to the natural, physical, and human environments. | Planning phase, DEIS completed, FEIS underway for SH 99, Segment H and I-1 | Retained |

| Project | Description (purpose, scope, known issues) | Status | Reason for Dismissal |
|---|---|---|---|
| FM 1008 Roadway Widening | South of the LBITP near Kenefick, Texas a roadway widening project is about 2.4 miles long from FM 2787 east to FM 1008.<br>**Known issues**: Construction related effects local, and limited, change in land use and habitat along the proposed ROW. | Completed | De minimis and therefore dismissed. |
| Bumstead Trust Property | An approximate 1,000-acre property for sale part of the Bumstead Trust property. Possible residential development in Harris and Liberty Counties, east of Lake Houston near Wolff Road (aka Cedar Bayou Road) and FM 2100 (near LBITP Parcel 42).<br>**Known issues**: Based on NWI maps, approximately 400 acres of property may contain waters of the United States, including wetlands, within the Cedar Bayou watershed that may be under threat of imminent development. | Possible | Retained |
| Piño Grande Residential Development | Residential development is planned for north-central Liberty County on about 2,000 acres east of the proposed Grand Parkway SH 99 and immediately north of the LBITP in the vicinity of Parcels 24 and 25.<br>**Known issues:** Based on similar investigations, approximately 20 percent of the landscape contains wetlands. Consistent with this percentage estimate based on similar landscape position, approximately 380 acres of wetlands could occur within the proposed development area. For this CEA, it would be assumed the estimated 380 acres of wetlands, riparian habitat, and wildlife habitat would be under threat of imminent development would be impacted. | Planned | Retained |
| Texas Land Fund No. 6 | An approximate 430-acre residential development is planned for northeastern Harris County east of Lake Houston near Wolff Road and FM 2100. The potential development is planned north of Parcel 50.<br>**Known issues**: Based on investigations for the LBITP possibly as much as 10 percent (%) of the area of this property would be estimated to contain waters of the United States, including wetlands. An estimate on a percentage basis (10% of 430 acres) is estimated to be 43 acres of potential impacts to waters of the United States, riparian habitat, and wetlands that would be under threat of imminent development. | Planned | Retained |
| SH 321 Union Pacific (UP) Railroad (RR) Bridge Replacement | The northbound Union Pacific (UP) Railroad (RR) overpass at SH 321 in Liberty County will be replaced by TxDOT. **Known issues**: This project would have no impacts to waters of the United States or other natural, physical, or socioeconomic resources. Limited ROW construction related impacts would occur. | Completed | De minimis and therefore dismissed. |

| Project | Description (purpose, scope, known issues) | Status | Reason for Dismissal |
|---|---|---|---|
| Trinity River National Wildlife Refuge (NWR) system acquisition boundary for the Floodplain Management System | The USFWS has established the TRNWR acquisition boundary along the floodplain of the Trinity River in Liberty County, Texas. **Known issues**: Natural resources management and Federal protection of floodplain resources, sensitive habitat, aquatic resources, Trinity River habitat, fisheries resources. | Property along and within the floodplain of the Trinity River an active acquisition goal of the U.S. Fish and Wildlife Service | Retained |
| Lake Wallisville Saltwater Barrier and Trinity River Bank Protection Plan | Lake Wallisville is operated by the Corps of Engineers for water storage, salinity control, and recreation. Lake Livingston no longer needs to release 1,000 cfs of water on an as-needed basis during the period from May 15 to September 15 each year to control salinity. The operation of Lake Wallisville allows this formerly discharged water to be used for water supply, and when Lake Livingston and Lake Wallisville are operated as system, provides an additional 140 MGD of maximum dependable yield from Lake Livingston. **Known issues:** Lake Wallisville provides Essential Fish Habitat (EFH) and an estuarine environment that support nursery and feeding areas for commercial and sport fishes, red drum and white and brown shrimp. The EFH has been designated for the following species that may be present: brown and white shrimp, and red drum. | Constructed of Lake Wallisville completed and operational in 2008-2009 and the Trinity River bank protection project is anticipated to have been completed in 2010. | Retained |
| Northeast Water Purification Plant (NEWPP) Expansion | NEWPP will be expanded to be able to treat raw water supplied to Lake Houston from the proposed LBITP. Proposed expansion of the NEWPP on Lake Houston will encompass the entire property footprint of approximately 260 acres. Turner Collie & Braden Inc. conducted a preliminary siting study of the NEWPP property in 1995 and known issues are identified based on that study. **Known issues**: In 1995, approximately 30 acres of the property were identified as waters of the United States, including wetlands, and these resources would potentially be impacted by the proposed expansion project. As an example, site 41HR571 adjacent to Lake Houston was identified with intact cultural deposits in the 260 acre property under investigation and expansion of the facility would also need to include an evaluation for the presence of cultural resources. | Anticipated to be completed prior to 2019; RFQ/RQP issued for design-build or alternative delivery construction will likely be issued in 2013 to allow for a 3 year design and 5 year construction schedule. | Retained |
| SHECO to provide electrical power through an 138-kV electrical power distribution system extended from the Tarkington Substation to proposed Capers Ridge Pump Station (CRPS) | The construction of an overhead electrical power line from the Tarkington Substation to the CRPS (7 miles within a 100-foot ROW) to provide service to the proposed CRPS. **Known issues**: Electrical towers would be supported on concrete pads of limited areal extent and spacing of xx feet. The easement and construction of the overhead electrical distribution line would affect ___ acres of land based on an analysis of various alternative alignments that were identified during preliminary studies. An approximate estimate of xx acres of waters of the United States, including wetlands and other natural resources may be affected by the project. | Permit needed from the Public Utilities Commission (PUC) prior to construction and operation. These actions are anticipated to be completed prior to 2019 in order to meet LBITP operational deadlines. | Retained |

| Project | Description (purpose, scope, known issues) | Status | Reason for Dismissal |
|---|---|---|---|
| Cedar Bayou Watershed Protection Plan | Cedar Bayou is a southward flowing stream originating in Liberty County and enters Galveston Bay approximately 60 miles from its headwaters. The watershed encompasses approximately 202 square miles with approximately 128 miles of open streams that are vitally important to the Galveston Bay system fisheries and other wildlife resources. **Known issues**: Cedar Bayou has been identified as an impaired stream segment. Houston-Galveston Area Council (HGAC) applied for and received a 319(h) grant from EPA to prepare a watershed protection plan for the Cedar Bayou watershed (HGAC 2011). Reduced water quality in Cedar Bayou and its tributaries related to upper watershed development through farming, sanitary sewer and septic systems, avian and terrestrial wildlife, and domestic animals are all sources for adverse effects to water quality in the watershed. Other concerns include increased sediment loads from altered drainage patterns due to continued urban development in the watershed, impacts to floodplains and sensitive habitats, habitat fragmentation and degradation and loss through time of wetlands and floodplains resources associated with industrial/pipeline development and land use change to agriculture and farming with resultant loss of emergent vegetation and fringe wetlands that provide critical habitat to wildlife species in Galveston Bay estuaries on a watershed scale. | Cedar Bayou Watershed Protection Plan ("Plan") completed by October 2013 under direction of HGAC. Based on targeted water quality sampling and analysis, a watershed source survey, comprehensive GIS inventory, water quality data analyses using Load Duration Curves and spatially explicit modeling, in order to establish and provide direction for Plan development and goals for implementation of monitoring, mitigation, adaptive management to preserve critical floodplain, wetlands, and vegetation needed for water quality improvement to Galveston Bay. | Retained |

Houston currently operates three surface water treatment plants: NEWPP, EWPP, and the Southeast Water Purification Plant (SEWPP). The primary customers for treated water from NEWPP and EWPP are NHCRWA, CHCRWA, WHCRWA (after 2013), and NFBWA (after 2025). Lake Houston is the sole raw water source for NEWPP and a partial source for EWPP. Trinity River water conveyed by the proposed project to Lake Houston would need to begin no later than 2020 to meet projected demands. The City of Houston would need to treat water at NEWPP and EWPP to meet demands by the City's water customers. To meet forecasted contracted water demand allocations with existing supplies, LBITP would supply 230 MGD in 2020 and 450 MGD in 2040 under permit to Lake Houston for treatment at NEWPP and EWPP and distribution to water customers in Region H.

#### 5.2.1.3 Direct Effects Summary (Economics)

Direct effects for economics related to the implementation of the three action alternatives is the cost for the displacement of residential or other development, economic issues related to area farming, natural resource exploration, and effects on adjacent or sensitive land use areas.

In addition to these economic consequences, the further south from Alternative 3A the proposed action alternative is located, the more, by comparison, the area becomes populated and the land developed. For facilities like public water supply conveyance, the more remote locations or routings are preferable, because risks to the conveyance itself and to the exposed supplies in canals are less susceptible to purposeful or inadvertent human impact. One of the outcomes of the Department of Homeland Security's Presidential Directives (HSPDs) and the Public Health Security and Bioterrorism Preparedness and Response Act (Bioterrorism Act) of 2002 specifically denote the responsibilities of EPA and the water sector in:

- Assessing vulnerabilities of water utilities
- Developing strategies for responding to and preparing for emergencies and incidents
- Promoting information exchange among stakeholders
- Developing and using technological advances in water security

These directives and laws supplement existing legislation, such as the Safe Drinking Water Act and the Clean Water Act, which have always had the goals of promoting a clean and safe supply of water for the nation's population and protecting the integrity of the nation's waterways. These directives and laws affect the actions and obligations of EPA, the Water Security Division, and water utilities (see **Chapter 4**, **Section 4.9.12**). *Guidelines for Physical Security of Water Utilities* was developed for the EPA by the American Society of Civil Engineers and the American Water Works Association.
Under HSPD 7, the Water Security Division has been tasked with developing a water sector specific plan as input to the National Infrastructure Protection Plan that the Department of Homeland Security must produce. The sector specific plan must address processes for:

- Identifying assets within the sector
- Identifying and assessing vulnerabilities, and prioritizing assets within the sector
- Developing sector specific strategic protective programs
- Measuring the effectiveness of the sector specific critical infrastructure protection program

HSPD 8 establishes policies to strengthen the preparedness to prevent and respond to threatened or actual domestic terrorist attacks, major disasters, and other emergencies by establishing mechanisms for improved delivery of federal preparedness assistance to state and local governments.

Under HSPD 9, EPA is to develop a robust, comprehensive surveillance and monitoring program to provide early warning in the event of a terrorist attack using biological, chemical, or radiological contaminants. HSPD 9 also directs EPA to develop a nationwide laboratory network to support the routine monitoring and response requirements of the surveillance program. HSPD 10, which is currently a classified document, basically reaffirms EPA's responsibilities under HSPD 9 while adding a clear directive on the Agency's responsibilities in decontamination efforts.

***Water Security Initiative***: EPA is implementing a demonstration project program to design, deploy, and evaluate a model contamination warning system for drinking water security. The program, which is being developed in partnership with select cities and laboratories, responds to a Homeland Security Presidential Directive that charges EPA to develop surveillance and monitoring systems to provide early detection of water contamination.

***Water Laboratory Alliance***: The purpose of the WLA is to provide the drinking water sector with an integrated nationwide network of laboratories with the analytical capabilities and capacity to support monitoring and surveillance, response, and remediation of intentional and unintentional drinking water supply contamination events involving chemical, biological, and radiochemical contaminants.

HSPD 10 provides directives to further strengthen the Biodefense Program through threat awareness, prevention and protection, surveillance and detection, and response and recovery.

The Water Sector-Specific Plan is a broad-based Water Sector critical infrastructure protection implementation strategy developed under the Department of Homeland Security's National Infrastructure Protection Plan and was produced by EPA in coordination with Water Sector security partners which includes our Water Sector Coordinating Council and Government Coordinating Council. The Water SSP is an annex to the 2010 National Infrastructure Protection Plan. *The costs associated with compliance with these directives have not been evaluated for the proposed LBITP, although these direct, long-term and necessary costs for compliance are expected to increase with time and would not result in minimal expense*. *The costs for implementing the project would be shared by the water customers of the City of Houston and it is anticipated that state water funds at favorable terms and interest rates would be available for the LBITP from actions taken during the upcoming 2013 Texas Legislative session. The implementation of the LBITP would result in increased rates for water supply thus indirectly affecting the water bills of area residents from when the project is constructed in 2019 or 2020 through the design life of the project (until 2040). A Water Rate Study has not been developed for the LBITP and thus costs to area residents on a per gallon use basis is not available as far as is known.*

**Summary Construction and O&M Costs for Alternatives 3A, 4 and 6**

The cost of constructing Alternative 3A, Alternative 4, and Alternative 6 are estimated below in 2012 dollars and 2014 dollars (**Table 5-3**). The O&M costs for Alternatives 3A, 4 and 6 are summarized by **Table 5-4** also in 2012 and 2014 dollars.

**Table 5-3:**
**Present Worth Value Analysis by Alternative**

| 2012 Dollars | |
|---|---|
| Capacity = 400 MGD<br>Interest Rate = 0.06<br>Inflation Rate = 0.03 | |
| Alternative | Construction Costs |
| 3a | $214,929,413 |
| 4 | $561,204,579 |
| 6 | $465,680,396 |

| 2014 Dollars | |
|---|---|
| Capacity = 400 MGD<br>Interest Rate = 0.06<br>Inflation Rate = 0.03 | |
| Alternative | Construction Costs |
| 3a | $228,018,615 |
| 4 | $595,381,938 |
| 6 | $494,040,332 |

**Table 5-4:**
**O&M Costs by Alternative**

| 2012 Dollars | |
|---|---|
| Capacity = 400 MGD<br>Interest Rate = 0.06<br>Inflation Rate = 0.03 | |
| Alternative | O&M Costs |
| 3a | $12,000,000 |
| 4 | $11,000,000 |
| 6 | $10,000,000 |

| 2014 Dollars | |
|---|---|
| Capacity = 400 MGD<br>Interest Rate = 0.06<br>Inflation Rate = 0.03 | |
| Alternative | O&M Costs |
| 3a | $13,101,600 |
| 4 | $12,009,800 |
| 6 | $10,918,000 |

Constructing the proposed LBITP would directly affect local, regional, and state employment, output, and income. Direct effects include those arising from purchases made related to construction activities such as gasoline, fuel for equipment and supplies, housing, food, supplies, equipment, rental or leased equipment, and other goods and services. Direct costs include wages and salaries paid to workers directly engaged in the project's construction, and capital costs for equipment, materials, and supplies during construction.

In the short term, implementing the LBITP would have a beneficial effect on the area's economy by creating construction and related jobs. During construction, area businesses such as gas stations, convenience stores, and restaurants would likely experience revenue growth due to increased construction workers in the communities. The proposed project would probably create less than 10 permanent jobs for CRPS and TRPS operators and LBITP-related maintenance activities.

The proposed LBITP poses significant effects to farmlands from a physical standpoint (land loss), from an income generation perspective, and from a tax revenue loss standpoint. A detailed analysis was developed for each alternative for farm income to producers foregone and tax revenue foregone (Holloway 2012). Farm income also includes timber production income. The results indicate that adverse impacts to farm and agricultural income associated with Alternative 3A, 4, and 6 may occur and are itemized in more detail below.

#### 5.2.1.3.1 Alternative 3A

More than 4,000 acres of property affecting all or part of 54 parcels of land in Liberty and Harris Counties would be acquired for Alternative 3A. These acres would be removed from the tax rolls and the change of land use from private to public would result in a decrease in property tax revenue for Harris and Liberty Counties, Texas, excluding the approximate 3,000 acre proposed mitigation property that was acquired by Coastal Water Authority (at a cost of approximately $xx million). The anticipated construction costs of Alternative 3A are estimated at $228 million in 2014 dollars (see also **Chapter 2.8.17**). The loss of total yearly net income to producers from the loss of property production (including food, fiber, and timber) is estimated at $7,130 for Liberty County producers and $1,652 for Harris County producers for a total of $8,782 for Alternative 3A (or a 5.8 percent loss of total yearly net income to producers). The loss of foregone annual tax revenue for Alternative 3A (representing the change from private to public land) is estimated at $6,015 (Holloway 2012). These two cost estimates do not include the loss of net income to producers and the loss of tax revenues for the 3,000 acre proposed mitigation property in Liberty County.

The overall cost to provide power to CRPS (Alternatives 3A) would be approximately $9,850,000 in 2010 dollars, excluding point of delivery construction costs that may be as much as $2 million (Power Engineers 2010).

#### 5.2.1.3.2 Alternative 4

Approximately 4,000 acres of property affecting portions of 228 parcels of land that would be acquired for Alternative 4 at a cost estimated at approximately $6.6 million (Kottke 2012), excluding the cost of the mitigation property that was acquired by the Coastal Water Authority at a cost of approximately $xx million. The anticipated construction costs of Alternative 4 are estimated at $595 million in 2014 dollars (see also **Chapter 2.8.17**). These properties would also be removed from the tax rolls, creating a decrease in property tax revenue for Harris and Liberty Counties, Texas, excluding the approximate 3,000 acre proposed mitigation property. Construction costs of Alternative 4 are estimated at $561 million in 2014 dollars (see also **Chapter 2.8.17**).

The loss of total yearly net income to producers from the loss of property production (including food, fiber, and timber) is estimated at $619 for Liberty County producers and $1,696 for Harris County producers for a total of $2,315 or less than 2.5 percent loss to yearly net income forgone to producers. Alternative 4 pose significant effects from a tax revenue loss standpoint because the annual tax revenue losses for Alternative 4 are estimated at $125,000. These two cost estimates do not include the loss of net income to producers and the loss of tax revenues for the approximate 3,000 acre proposed mitigation property in Liberty County.

The overall cost to provide power to CRPS (Alternative 4) would be approximately $9,850,000 in 2010 dollars, excluding point of delivery construction costs that may be as much as $2 million (Power Engineers 2010).

#### 5.2.1.3.3 Alternative 6

Less than 4,000 acres of property in 156 parcels of land would be acquired for Alternative 6 at a cost estimated at approximately $4.18 million (Kottke 2012), excluding the cost of the mitigation property that was acquired by the Coastal Water Authority at a cost of approximately $xx million. These properties would also be removed from the tax rolls, creating a decrease in property tax revenue for Harris and Liberty Counties, Texas, excluding the approximate 3,000 acre proposed mitigation property. Construction costs of Alternative 6 are estimated at $494 million in 2014 dollars (see also **Chapter 2.8.17**). The loss of total yearly net income to producers from the loss of property production (including food, fiber, and timber) is estimated at $19,372 for Liberty County producers and $2,694 for Harris County producers for a total of $22,066 or a 24.2 percent loss to yearly net income foregone to producers. This percentage reflects the total yearly net income to producers foregone with ROW acquisition and use for public water supply. Foregone annual tax revenue losses for Alternative 6 would be $227,391.

Power redundancy provisions at the TRPS (Alternative 6) could cost between $5 million to $15 million in 2003 dollars depending on the option implemented (recommended option is approximately $10.5 million; KBR 2003). Alternative or redundancy power sources considered are additional second 138 kV transmission line, power lines from a separate power source, onsite diesel or natural gas stand-by generators, and possibly other sources. These recommendations may have already been implemented by the Applicant.

**Physical Security of the Proposed CRPS and Existing TRPS, Alternatives 3A, 4 and 6:** The developed portion of this site, where the pump station, control building, electrical switchyard, electrical building, maintenance building, etc. are located, will have a constructed perimeter fence. The fence would be constructed along the river and bayou/lake shoreline to the pump station or discharge location on both sides to prevent access to these facilities. This perimeter fence will be constructed to resist climbing or cutting. The fence fabric will be heavy gauge chain link or welded wire fabric construction that would be least 6 feet tall with double outriggers on top with either three strands of barbed wire on both sets of outriggers or coiled razor wire.

The entrance gate into this area will be an automated type sliding gate. Access through the gate will be controlled by the access control functions of the integrated security system. All manholes, valve, vault hatches, equipment control cabinets, control devices, etc would need to be secured with shrouded locks. All personnel doors into the facilities at this site will be equipped with tamper resistant security hinges and key-locked doors. Each main entrance into each building will also be equipped with an access control card reader and associated hardware. Any roof hatches or exterior roof access ladders would need to be locked.

**Electronic Security for the Proposed CRPS (Alternatives 3A and 4) and Existing TRPS (Alternative 6):** Electronic security for this facility consists of access control for the main gate, and each of the main buildings, specifically the control building, electrical building, and maintenance building and would include CCTV coverage of the entrances into each of these buildings, the main gate and the pump station. The CCTV coverage of the building entrances is from the inside of the buildings looking out in order to obtain a usable image for identifying who is entering the building. The camera at the entry gate will require lighting for use 24 hours per day and 7 days per week and the camera overlooking the proposed CRPS and existing TRPS would require continuous lighting for operations and monitoring. Lighting at the CRPS would be required regardless of occupancy conditions although lights have been requested to be down-shielded to minimize effects of light pollution on wildlife.

Communications between the water control systems operated by the Coastal Water Authority, the TRA, and at Lake Houston would be required. All new facilities would need to comply with Occupational Safety and Health Administration (OSHA) regulations, EPA requirements for security, and building codes specified by the City of Dayton and/or Liberty County where construction is planned to occur. A Supervisory Control & Data Acquisition System (SCADA) system would also be required to assure proper operations of the entire system. Electronic security of the SCADA system would be needed to prevent unauthorized use of the system.

In addition to the facilities surrounding the proposed or existing pump station, additional facilities would be needed at various locations along the pipeline or canal route. The number and extent of these facilities depends on the frequency of maintenance, need for flow or other control measures, and the length of the canal or pipeline segment.

**Alternative Conveyance Facilities (Pipeline vs Open Earthen Canal):** The pipeline segments for Alternative 3A 4, and 6 would consist of two, 9-foot in diameter pipelines buried 6 feet below the surface with the base of the pipelines resting at approximately 15 feet below the land surface elevation. The pipeline easements would consist of graded, mounded, and maintained easements that would include access roads and fences (two, side-by-side 9-foot diameter pipes installed up to 15 feet deep) and would permanently change local topography along the pipeline route for Alternative 4 that would extend more than 15 miles across the north-central portion of Liberty County. Alternative 6 would extend more than 10 miles across central Liberty County. Although the ROWs would be re-contoured after construction, it is expected that the surface expression of the pipeline easement would be at least 23 miles (Alternative 4) or 21 miles (Alternative 6) long. The surface expression of the project would be linear, elevated, mounded, and bermed surface feature with side access roads, fencing, and drainage ditches.

#### 5.2.1.3.4 Alternative 3A

For Alternative 3A, the proposed canal would extend a distance of approximately 23 miles across northern Liberty County and would consist of an earthen, open channel canal with 4:1 side slopes and flow control structures. The average depth of water in the open canal is anticipated to be seven feet. To maintain this water surface elevation, water level control gates would need to be installed along the LBITP canal at various points to be identified during final design. In general, these gates would operate under gravity and would allow more water through the structure when upstream flow levels increase and would restrict water passage when upstream flows levels drop below a certain elevation. For all alternatives, the above ground valves, controls, and other facilities or equipment would need to be locked with shrouded locks.

There are two locations along the proposed Alternative 3A canal that may require the addition of security enhancements. The first is the water control structure. The PLC cabinets, manual controls and valves need to be locked using shrouded locks. The second is at the canal maintenance facility. This maintenance facility will be surrounded by a perimeter fence. This perimeter fence will be constructed to resist climbing or cutting. The fence fabric will be heavy gauge chain link or welded wire fabric construction and should be at least 6 feet tall with double outriggers on top with either three strands of barbed wire on both sets of outriggers or coiled razor wire. The entrance gate into this area will be an automated type sliding gate. The gate providing direct access to the canal will be secured with a shrouded lock. Access through the main gate will be controlled by the access control functions of the integrated security system at the site that will be discussed under the Electronic Security section. All manholes, valve, vault hatches, equipment control cabinets, control devices, etc will be secured with shrouded locks. All personnel doors into the facilities at this site will be equipped with tamper resistant security hinges and key-locked doors. Each main entrance into each building will also be equipped with an access control card reader and associated hardware. All roof hatches or exterior roof access ladders will be locked. Electronic security for this facility consists of access control for the main gate, and each of the main buildings, specifically the offices, vehicle maintenance bays, parts storage, general maintenance, and used oil storage. Security cameras would include CCTV coverage of the entrances into each of these buildings/facilities and the main gate. The CCTV coverage of the building entrances is from the inside of the buildings looking out in order to obtain a usable image for identifying who is entering the building. The camera at the entry gate will require lighting for use at all times. Communications between these systems and the monitoring point at the Coastal Water Authority would occur. All PLC cabinets, control valves, etc. associated the proposed canal would need to be secured with shrouded locks.

For Alternative 3A, other than the proposed surrounding wildlife friendly, barb-wire fence, there would be no additional security enhancements other than fencing that would be needed for the earthen open canal due to the control of much of the property adjoining the canal by large-scale landowners and lack of property access. The goals of water supply protection/security and wildlife mobility would need to be addressed during preliminary and final design of the LBITP.

#### 5.2.1.3.5 Alternative 4

Alternative 4 is approximately 23.9 miles long and directly affects approximately 885 acres of land (excluding the proposed approximate 90-acre CRPS and the proposed 10 acre maintenance facility). It is anticipated that due to the nature and location of area development combined with the location of Alternative 4, a significant portion of the proposed pipeline alignment and easement would need security enhancements. The length of the proposed pipeline easement would increase the costs of fencing, CCTV cameras, and other security features. Site-specific studies related to Alternative 4 security needs have not been developed although it is anticipated that costs for proposed pipeline security may exceed $10 million. The goals of water supply protection/security and wildlife mobility would need to be addressed during preliminary and final design of the LBITP.

#### 5.2.1.3.6 Alternative 6

Alternative 6 is 21.4 miles long and directly affects approximately 725 acres of land (excluding the TRPS and the proposed 10 acre maintenance facility). It is anticipated that due to the nature and location of area development combined with the location of Alternative 6, a significant portion of the proposed pipeline alignment and easement would need security enhancements. The length of the proposed pipeline easement would increase the costs of fencing, CCTV cameras, and other security features. Site-specific studies related to Alternative 6 security needs have not been developed although it is anticipated that costs for proposed pipeline security may exceed $10 million. The goals of water supply protection/security and wildlife mobility would need to be addressed during preliminary and final design of the LBITP.

### 5.2.1.4 Indirect Effects Summary (Economics)

Constructing the proposed LBITP (Alternative 3A, 4 or 6) would have indirect and induced effects on local, regional, and state employment, output, and income. Indirect effects to population and demographics would be expected as the LBITP would meet Region H and the Houston area water demands as a recommended strategy for 11 million future residents.

Population projections are included with the TWDB 2012 State Water Plan and the Initially Prepared (IPP) Region H RWP published in 2011. Implementing the LBITP would result in indirect economic impacts to Region H that could include the following indirect economic effects:

- Costs for additional capacity lines throughout the LBITP service area with related construction activities and economic impacts (data not readily available)
- Increased use of public facilities, infrastructure, utilities, and public services due to increased population in Region H (data not available)
- Local economy stimulated from circulating construction spending (personal income of $63 million)

The indirect effects for the RSA include the potential impacts from unmet water needs on a number of economic indicators. TWDB prepared the *Socioeconomic Impacts of Unmet Water Needs in the Region H Water Planning Area* report in 2005 to evaluate the impacts from not managing water needs in Region H, including LBITP. This report was updated in 2010. Major economic indicators include lost output (sales), income, business taxes, and jobs. Socioeconomic impacts are divided by sector for each indicator not directly related to water service. Based on TWDB's analyses, implementing the LBITP would prevent the loss of $9 billion in sales and 75,000 jobs in the Region H boundary for economics through 2060.

Primary indirect effects to economics would result from area development that would occur in part regardless of the proposed project, although without sufficient and sustainable, long-term, cost effective supplies of water, businesses would elect not locate or expand in the Houston area. This would affect employment and therefore population growth, limit tax revenues, loss to state legislative budgets, less available monies for state and related federal funding of needed infrastructure improvements and programs, and would diminish public health, safety, and well-being. The TRPS (Alternative 6) and a portion of its conveyance facilities are potentially subject to both wind and storm surge effects because of their proximity to Galveston Bay and coastal areas.

#### 5.2.1.5 Other Reasonably Foreseeable Effects

The economics RSA is the LBITP water supply area, generally the Region H boundary established by the TWDB (**Figure 5-1**). Participating LBITP third parties including the NHCRWA, WHCRWA, CHCRWA, and NFBWA all have their own water supply plans established. These water supply plans have reasonably foreseeable economic effects on water supply in the Region H area.

#### 5.2.1.6 Cumulative Effects Analysis (CEA) Results

The primary cumulative impacts from the LBITP of the RSA for economics described by the Region H boundary would be associated with the result of development induced by the cost-efficient water supply. Several factors such as transportation, economics, schools, available land, and favorable development codes would contribute to anticipated development trends.

#### 5.2.1.7 Mitigation Opportunities

Development in the RSA described for economics would be subject to the City of Houston, Harris County subdivision rules, homeowner's association rules, and floodplain construction restrictions. Many of the larger master planned developments incorporate concepts to maximize detention, open space, and aesthetics. Commercial centers and pockets with mixed use may also be incorporated to provide employment and travel options for residents. These development practices may reduce the overall impact the development would have on economic resources. State and federal regulatory agencies are required to institute policies and monitor project-level effects to the natural and cultural resources that are found in their jurisdictions. Avoidance, minimization, and mitigation strategies are used to support those policies to reduce impacts on these resources. Should the TRPS be adversely affected by storm impacts (wind and hurricane surge), redundancy in the pumping system that would be able to provide large volumes of water necessary for Houston metropolitan residential, commercial, and industrial customers appears to reinforce system reliability. Appropriate mitigation for direct impacts to resources from reasonably foreseeable projects would occur in compliance with appropriate and relevant laws, Act, regulations, and Executive Orders. Therefore, LBITP's regional effect to economics would result in a long-term benefit to human health and the environment.

### 5.2.2 Wetlands/Waters of the United States (U.S.)

#### 5.2.2.1 Resource Study Area (RSA) for Alternatives 3A, 4 and 6: Wetlands/Waters of the U.S.

No LBITP alternative conveyance route would avoid all impact to wetlands or waters of the U.S., including wetlands. Each alternative alignment contains these special aquatic sites. Any proposal to locate a conveyance pipeline or canal on any alternative route would therefore involve impacts to the aquatic ecosystem, and would be subject to the same permitting concerns as the Alternative 3A. In the evaluation conducted, neither the USACE nor the Applicant has identified a contiguous conveyance route in the study area which is completely within uplands. The absence of a suitable upland route required analyzing numerous alternatives, and each presents its own environmental issues.

#### 5.2.2.1.1 Alternative 3A

**Figure 5-3** provides the RSA for wetlands/waters of the U.S. for Alternative 3A. The RSA for waters of the United States is the same as for wetlands, and the wetlands/waters of the U.S. RSA includes the watersheds intersecting Alternative 3A: East Fork San Jacinto River, Upper Galveston Bay and the Lower Trinity River. Due to the East Fork San Jacinto River watershed's large size, the northern sub-basins were not included in the RSA. The included sub-basins drain into the East Fork San Jacinto River. The RSA for wetlands includes more than 1,204,900 acres in Liberty, Harris, Montgomery, San Jacinto, and Chambers Counties, Texas. The USACE has jurisdiction over waters of the United States in Texas. For this analysis, a distinction was not made between jurisdictional and non-jurisdictional waters of the United States, including wetlands. The temporal boundary extends from the mid-1970s (based on Texas Costal Basins Report dated 1977) and National Wetlands Inventory (NWI) dataset (1989) to 2040, which is the horizon for the indirect and cumulative impact analysis.

#### 5.2.2.1.2 Alternatives 4 and 6

**Figure 5-4** provides the wetlands/waters of the U.S. RSA for Alternatives 4 and 6. The RSA for waters of the United States is the same as for wetlands, and the wetlands/waters of the U.S. RSA includes the watersheds intersecting the alternatives including Cedar Bayou, Upper Galveston Bay and the Lower Trinity River. A watershed approach to analyze cumulative effects to waters of the United States was used for the same reasons provided above for wetlands resources. Alternatives 4 and 6 would be located through five bayou floodplains, the largest of which would be the Cedar Bayou floodplain. The upper portion of the Cedar Bayou watershed have been heavily affected by agricultural production since the 1940s, which uses the rich, prime farmland soil in these areas. The Cedar Bayou watershed between FM 1960 and several miles south of US 90 remained in dense wetland forest until at least the mid-1960s. Since that time, forested floodplain at this location has been incrementally removed through logging, agricultural expansion, oil and gas development, industrial and commercial development and other urban (residential) land uses.

### 5.2.2.2 Current Health and Historical Context Summary

Since the 1950s, substantial losses have occurred to wetlands and other critical habitats, and in turn wildlife habitat diversity, in the Houston Gulf Coast Region. Continued urbanization and industrialization in the Houston area would continue to cause pressure on remaining habitats and the ecosystem. Liberty, San Jacinto, and Chambers Counties have experienced moderate growth over the last 30 years. Eastern Harris County and southern Montgomery Counties have experienced significant population growth and development since the 1970s, especially in the last 20 to 30 years since the 1989 NWI maps were published.

Riparian ecosystems occur along streams, Cedar Bayou, Luce Bayou, and the lower Trinity River especially in floodplains. The riparian corridor encompasses the stream channel and that portion of the terrestrial landscape from water’s edge landward, where vegetation may be influenced by river-influenced water tables or flooding, and by the ability of soils to hold water. Riparian vegetation refers to the vegetation growing within the riparian corridor. Since riparian settings are interfaces between terrestrial and aquatic systems, ecological processes in those settings are dependent on both the dynamics of the associated uplands and the streams. Riparian vegetation plays an important role in water quality functions of riverine systems and influences other biologically important water quality parameters such as dissolved oxygen and temperature. Riparian vegetation is an important component of the aquatic faunal habitat and these effects include (a) provision of fish cover (b) provision of streambank stability (c) regulation of stream temperatures (d) input of nutrients to the system and (e) direct input of invertebrates as fish food.

Over the past 15 to 20 years, agencies and local governments have moved toward managing water resources by using the watershed approach (EPA 2005). Waters of the United States include jurisdictional wetlands, navigable waters, and tidally influenced waters. According to a USFWS report for wetlands status and trends in the conterminous United States, between 2004 and 2009, freshwater wetlands types (including freshwater emergent marshes, freshwater shrubs, freshwater-forested wetlands, and freshwater ponds) experienced an estimated net gain of approximately 21,900 acres (Dahl 2011).

The modification to drainage in the area improves surface water or overland flow, but reduces the natural diversity of the stream channels and may potentially remove riparian habitat. Streams and bayous present in the Lower Trinity River, and Cedar and Luce Bayous watersheds have been altered over time Some RSA streams, bayous and surface water features remain relatively naturalized, although local impact caused by forestry and agricultural activities have occurred. Most impacts involved removing streamside vegetation and altering hydrology.

The structure and function of vegetation of Cedar Bayou's humid riparian are dominated by overland flows. Large, complex floodplains develop and include a large percentage of wetlands by area. Riparian vegetation varies by type, size and distribution and the distribution patterns of riparian vegetation depend on moisture gradients (flooding and depth to groundwater), fluvial geomorphic landforms, and stream gradients. Riparian corridors provide critical wildlife habitat in many landscape settings. Riparian vegetation provides support for many wildlife requirements. The value of riparian areas of Cedar Bayou are related to their size and contiguity and are most valuable when they remain intact and form a continuous corridor for wildlife migration. Intact riparian vegetation areas are most valuable and provide significant ecosystem benefit. Riparian vegetation affects the hydraulic and hydrologic functions of streams and rivers through bank stabilization and reduction of water loss from evapotranspiration. Flood attenuation is also increased in vegetated riparian systems in areas with maintained stream morphology through vegetative anchoring.

Due to its importance providing remaining riparian vegetation and habitat, at its confluence with Galveston Bay, Cedar Bayou is a critical wildlife habitat (TPWD 2010). Due to its importance to the Galveston Bay system fisheries and other wildlife resources, and to concerns about its listing as an impaired stream (303(d)), the Houston-Galveston Area Council (HGAC) applied for and received a Section 319(h) grant from EPA to prepare a watershed protection plan for the Cedar Bayou watershed (HGAC 2011). HGAC has been working with local stakeholders to systematically study the watershed and develop a watershed protection plan.

### 5.2.2.3 Direct Effects Summary

#### 5.2.2.3.1 Wetlands/Waters of the U.S.

*Alternative 3A*

In order to evaluate direct effects to wetlands/waters of the U.S. using a consistent process since site-specific investigations have not been conducted for all action alternatives under investigation, the direct effects summary provided is based on graphical analyses conducted based on NWI maps. The approximate acreage of wetlands within the Alternative 3A ROW based on the PJD, is approximately 203 acres of freshwater aquatic resources. Of this total, approximately 118.93 acres are forested wetlands, 45.26 acres are emergent wetlands, 11.21 acres are open water, and 25.55 acres are scrub-shrub wetlands.

*Alternative 4*

In order to evaluate direct effects to wetlands/waters of the U.S. using a consistent process since site-specific investigations have not been conducted for all action alternatives under investigation, the direct effects summary provided is based on graphical analyses conducted based on NWI maps. The approximate acreage of NWI wetlands within the Alternative 4 ROW is 66 acres. This acreage does not impacts to Water of the U.S. and have not verified by the USACE.

*Alternative 6*

In order to evaluate direct effects to wetlands/waters of the U.S. using a consistent process since site-specific investigations have not been conducted for all action alternatives under investigation, the direct effects summary provided is based on graphical analyses conducted based on NWI maps. The approximate acreage of NWI wetlands within the Alternative 3A ROW is 82 acres. This acreage does not impacts to Water of the U.S. and have not verified by the USACE.

### 5.2.2.4 Indirect Effects Summary

#### 5.2.2.4.1 Alternative 3A

The proposed project would not have an indirect impact caused by induced development within the wetlands/waters of the U.S. RSA. Wetlands bisected by the proposed canal which occur inside and outside the ROW could potentially be impacted by the hydrology change. However, siphons have been designed to minimize and eliminate that impact. Siphon conveyance for the LBITP canal in below-grade culverts is designed to hydrologically connect wetland resources, thus avoiding possible degradation from constructing the canal. Precipitation is the major hydrology source for wetlands identified in LBITP canal's vicinity. To minimize possible degradation due to interrupting overland flow, 18 drainage crossings are included in the canal design to maintain hydrologically connected areas.

As previously discussed, because the proposed alignment is almost entirely outside the 100-year floodplains of major streams, the project will have little effect on natural riverine overflow, except in the most severe (infrequent) precipitation events. Therefore, wetlands outside the project alignment that depend on hydrology from riverine overflow are not anticipated to be affected by the project. In addition to the direct impacts from the canal alignment on wetlands resources, the canal channel and parallel berms present potential impediments to overland flow, some of which may supply runoff to wetlands located away from the alignment. Most wetlands outside the 100-year floodplain would be expected to be depressional in nature, and would therefore be expected to have direct precipitation as a hydrology source. However, the overland flow crossing features would be designed to convey all upgradient runoff volume across the canal alignment while minimizing the amount of initial rainfall and runoff volume through overland flow on the siphon structures' downgradient side. This will be done by designing the ditches to permanently hold water, which in effect, pre-charges the ditches with runoff volume. This design feature allows overland flow to continue across the canal alignment at the surface. Wetlands adjacent to but not directly impacted by the LBITP ROW which depend on runoff for hydrology are not expected to be significantly impacted.

Implementing the proposed project would not indirectly influence development within the wetlands/waters of the U.S. RSA. Property owners adjacent to the proposed canal would not have access to the raw water being conveyed to Lake Houston. Wetlands bisected by the proposed canal which occur inside and outside the ROW could potentially be impacted by the hydrology change. However, 18 siphons have been designed to minimize and eliminate that impact. Siphon conveyance for the LBITP canal in below-grade culverts is designed to hydrologically connect wetland resources, thus avoiding possible degradation from constructing the canal. Precipitation is the major hydrology source for wetlands identified in LBITP canal's vicinity.

As previously discussed, because the proposed Alternative 3A alignment is almost entirely outside the 100-year floodplains of major streams, the project will have little effect on natural riverine overflow, except in the most severe (infrequent) precipitation events. Therefore, wetlands outside the project alignment that depend on hydrology from riverine overflow are not anticipated to be affected by the project. In addition to the direct impacts from the canal alignment on wetlands resources, the canal channel and parallel berms present potential impediments to overland flow, some of which may supply runoff to wetlands located away from the alignment. Most wetlands outside the 100-year floodplain would be expected to be depressional in nature, and would therefore be expected to have direct precipitation as a hydrology source.

#### 5.2.2.4.2 Alternatives 4 and 6

To date, human induced impacts to the watershed have been found to contribute to reduced water quality in Cedar Bayou and its tributaries. Upper watershed development through farming, sanitary sewer and septic systems, avian and terrestrial wildlife, and domestic animals are all sources for adverse effects to water quality in the watershed.

Major additional concerns include increased sediment loads from altered drainage patterns due to continued urban development in the watershed. Alternatives 4 and 6 are located in the Cedar Bayou watershed, and water quality and sediment impacts through floodplain and related development are principal concerns. Although mitigation would occur, and overland flow/floodplain values maintained by siphon structures to reduce the potential for flood hazards, there would be a direct, long-term and permanent effect on the functioning and management of the watersheds of the San Jacinto, Cedar Bayou, lower Trinity River and Galveston Bay as a result of the implementation of the LBITP. Alternatives in the Cedar Bayou watershed would have to incorporate measures to minimize effects to sediment deposition in the Cedar Bayou and ensure ROWs maintenance activity did not further contribute to degraded water quality by using pesticides, insecticides, fertilizers or other ROW and facility maintenance program features. Despite implementing such measures, the risk of detrimental or adverse permanent effects to the Cedar Bayou watershed and to the Cedar Bayou itself from the water supply conveyance system construction and O&M would remain a long-term concern.

One reason why Alternative 6 affects few wetlands and riparian vegetation within the Cedar Bayou corridor is because these areas have systematically been destroyed due to past actions and therefore no longer exist to be affected. As a result, the aquatic resource acreage to be traversed by Alternative 6 represents a measurable portion of the remaining forest resources in this part of Cedar Bayou. Due to the historic loss of these resources, Cedar Bayou's remaining natural areas are under scientific study in light of this watershed's ecological contribution to upper Galveston Bay and the potential for restoring instream aquatic life to sustainable levels (HGAC 2012). Further development in this watershed at this location would likely contribute to the cumulative adverse impacts already affecting Cedar Bayou.

### 5.2.2.5 Other Reasonably Foreseeable Effects

Reasonably foreseeable projects in the RSA for wetlands/waters of the United States, including wetlands, include roadway projects and residential communities including large-scale master planned developments. Reasonably foreseeable projects in the RSA that may affect wetlands and waters of the United States include planned or proposed projects in the vicinity such as those summarized by **Table 5-2**, including identification of known issues. **Table 5-2** summarizes recently completed, present and reasonably foreseeable future actions in the RSAs under evaluation by this LBITP DEIS.

- ENSTOR Houston HUB Storage and Transportation, LP (Houston HUB Storage Project): This project is a high volume, natural gas storage facility designed for injection, storage, and withdrawing natural gas in and from salt caverns to be created in the North Dayton Salt Dome.
- Grand Parkway SH 99, Segments H and I-1 and I-69 (Trans-Texas Corridor): The Grand Parkway (SH 99) and the Trans-Texas Corridor (I-69) are planned to be constructed through Liberty County. The proposed I-69, Trans-Texas Corridor, is a State of Texas undertaking in the planning stages with an undetermined construction date. In the project vicinity, I-69 is consistent with SH 99.
- TRNWR Acquisition Boundary: The USFWS has established the TRNWR acquisition boundary along Trinity River's floodplain in Liberty County generally from the San Jacinto to the Chambers County boundary lines. This would result in beneficial impacts to aquatic resources or waters of the United States.
- Piño Grande: Residential development is planned for north-central Liberty County on about 2,000 acres east of the proposed Grand Parkway SH 99 and immediately north of the LBITP in the vicinity of Parcels 24 and 25. Based on investigations for the LBITP, approximately 20 percent of the landscape contains wetlands resources. If this percentage is applied to the proposed Piño Grande project (occurs in similar landscape), approximately 380 acres of wetlands could occur within the proposed development area. For this CEA, it would be assumed the estimated 380 acres of wetlands would be impacted.

- Bumstead Living Trust Property: An approximate 1,000-acre property for sale part of the Bumstead Trust property. Possible residential development in Harris and Liberty Counties, east of Lake Houston near Wolff Road (aka Cedar Bayou Road) and FM 2100 (near LBITP Parcel 42).
- Texas Land Fund No. 6: An approximate 430-acre residential development is planned for northeastern Harris County east of Lake Houston near Wolff Road and FM 2100. The potential development is planned north of Parcel 50.
- Fourteen additional county, city or state roads are proposed to be constructed or extended including: CR 668; CR 680; CR 6242; CR 677; CR 622; CR 686; CR 615; CR 609; CR 678; CR 2309; FM 1010; North Lake Houston Parkway; Bennie Terrell Road, and an unnamed collector. These projects may affect wetland resources but are minor improvements that would be implemented in compliance with wetlands protection regulations and requirements. For this reason, the effects of these projects on wetlands/waters of the U.S. are not quantified or considered in any additional detail.

Residential and commercial developments are likely to occur within the RSA, which could impact waters of the United States, including wetlands. These reasonably foreseeable projects could cause potential permanent degradation and loss of waters of the United States, including wetlands. The Region H RWP has also included some water management strategies involving constructing additional reservoirs or operating reservoirs in the Region H water planning area (see **Figure 5-1**).

The Federal mandate of “no net loss” of wetlands requires mitigating the loss of jurisdictional wetlands caused by roadway projects such as the SH 99/Grand Parkway. Jurisdictional wetlands lost as a direct impact of the proposed TxDOT, Harris County Toll Road, or Federal Highway Administration (FHWA) projects would likely be mitigated.

The land use analysis conducted indicates that none of the LBITP alternatives would induce development within the RSAs identified for waters of the United States, including wetlands. If development continues at its last 20 years pace, 150 acres of wetlands per year would be filled or impacted in the RSA, based on the NWI and aerial photography analysis. Considering the LBITP, SH 99/Grand Parkway, and proposed residential developments, the cumulative wetland impacts in the RSA could potentially be approximately 840 acres or nearly 0.25 percent of the remaining wetlands in the RSA. However, continued degradation and loss of wetlands in the RSA would be expected regardless of implementing the proposed project.

### 5.2.2.6 Cumulative Effects Analysis Results

The total acreage of NWI mapped wetlands within each planned, proposed or existing project footprint was calculated and summarized in each Wetlands/Waters of the U.S. RSA in **Tables 5-5 and 5-6**.

**Table 5-5:**
**NWI Impacts by Project within the Wetlands/Waters of the U.S. RSA for Alternative 3A**

| Project Description | Acres |
|---|---|
| Keystone XL Project | 400 |
| ENSTOR Houston HUB Storage and Transportation Facility, LP | 71 |
| Grand Parkway SH 99 | 174 |
| Texas Land Fund No. 6 | 22 |
| Bumstead Living Trust | 96 |
| Trinity River NWR System Acquisition Boundary for the Floodplain Management System | 58,100* |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | 9 |
| Piño Grande Residential Development | 380 |
| **Total Acres of Additional Wetlands Impacts within the RSA** | 802 |

* The Trinity River NWR System property acquisition would have a positive impact on preservation of the wetlands/Waters of the U.S. within the RSA. These are impacts to NWI mapped wetlands.

In total with direct including impacts estimated for Alternative 3A, there would be an approximate 1,005 acres cumulative impact to Wetlands/Waters of the U.S. within the Wetlands/Waters of the U.S. RSA for Alternative 3A. It is important to note 58,100 acres of wetlands are proposed to be preserved by the Trinity River NWR System Acquisition Boundary for the Floodplain Management System within the RSA.

**Table 5-6:**
**NWI Wetlands Impacts by Project within the Wetlands/Waters of the U.S. RSA for Alternatives 4 and 6**

| Project Description | Acres |
|---|---|
| Keystone XL Project | 385.69 |
| ENSTOR Houston HUB Storage and Transportation Facility, LP | 70.59 |
| Grand Parkway SH 99 | 118.24 |
| Texas Land Fund No. 6 | 21.72 |
| Bumstead Living Trust | 72.34 |
| Trinity River NWR System Acquisition Boundary for the Floodplain Management System | 57,964.22* |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | 6.65 |
| **Total Acres of Additional Wetlands Impacts within the RSA** | 680 |

* The Trinity River NWR System property acquisition would have a positive impact on preservation of the wetlands/Waters of the U.S. within the RSA. These are impacts to NWI mapped wetlands.

In total with direct including impacts estimated for Alternative 4, there would be an approximate 746 acres cumulative impact to Wetlands/Waters of the U.S. within the Wetlands/Waters of the U.S. RSA for Alternatives 4 and 6. It is important to note 57,964 acres of wetlands are proposed to be preserved by the Trinity River NWR System Acquisition Boundary for the Floodplain Management System within the RSA.

In total with direct including impacts estimated for Alternative 6, there would be an approximate 762 acres cumulative impact to Wetlands/Waters of the U.S. within the Wetlands/Waters of the U.S. RSA for Alternatives 4 and 6. It is important to note 57,964 acres of wetlands are proposed to be preserved by the Trinity River NWR System Acquisition Boundary for the Floodplain Management System within the RSA.

### 5.2.2.7 Mitigation Opportunities

To minimize possible degradation due to interrupting overland flow, 18 drainage crossings are included in the canal design to maintain hydrologically connected areas. Impacts to wetlands by private development are expected. Developers are required to identify and mitigate impacts to jurisdictional waters, including wetlands, according to federal requirements. Sensitive habitats such as wetlands are protected by Section 404 of the Clean Water Act. If unavoidable impacts to jurisdictional wetlands were anticipated, options would include on-site and off-site mitigation. On-site mitigation is not favored due to the isolated nature of a wetland for each development and the high costs to maintain it. Participation in large well-planned wetland projects such as Greens Bayou Wetland Mitigation Bank is more successful than smaller segmented mitigation efforts. Off-site mitigation would likely include purchasing credits within an approved wetlands mitigation bank or paying an in-lieu fee to another entity as compensation for anticipated adverse impacts. Mitigation options would continue to be investigated and evaluated by the project sponsors and appropriate regulatory and resource agencies throughout the project development process. A compensatory mitigation plan would be prepared, as necessary, and submitted to the USACE as part of a Section 404 IP application.

All alternatives for the LBITP would potentially result in direct, unavoidable permanent impacts to waters of the United States, including wetlands. A 3,000-acre land parcel adjacent to the Trinity River in the far northeastern portion of the LBITP has been identified as a proposed site for compensatory mitigation of anticipated project impacts to wetlands and other aquatic resources.

Approximately 1,224 acres of aquatic resources were identified within the mitigation site, including about 1,208 acres of wetlands and 16 acres of drainages and ponds. The identified wetlands include roughly 964 acres of forested wetlands, about 6 acres of emergent wetlands, nearly 25 acres of scrub-shrub wetlands, and about 213 acres of a large wetland area containing forested, emergent and scrub-shrub components. Uplands within the mitigation site include approximately 879-forested acres, 328 acres of pastureland; 61 acres of scrub-shrub, 479 acres of mosaic forested upland and 40 acres of scrub-shrub mosaic upland.

CWA has acquired the proposed approximate 3,000-acre mitigation property along the lower Trinity River in order to provide for mitigation of Alternative 3A through preservation. The property will be conveyed to the USFWS as part of the TRNWR. The majority of the property is forested; however, an area in the site's southeastern part has been cleared and was formerly used as pasture.

Impacts to waters of the United States by private development may occur in the RSA. Private developments are required to identify and mitigate impacts to all waters of the United States, according to Federal requirements stipulated by compliance with the Clean Water Act.

## 5.2.3 Vegetation/Wildlife Habitat

### 5.2.3.1 Resource Study Area (RSA)

The RSA for vegetation and wildlife can be recognized as the southwestern portion of the Austroriparian Biotic Province, in relation to the vicinity of the Trinity River National Wildlife Refuge, where the proposed project traverses.

The RSA for Alternative 3A (**Figure 5-6**) includes pine-hardwood forests, crops, and willow oak-water oak-blackgum forest (TPWD's *The Vegetation Types of Texas*, Gould 1976) vegetation types, and is within the Trinity River Basin and includes Luce Bayou, Lake Houston, and the Trinity River. This RSA can be defined as being bordered by the Trinity River to the east, Lake Houston and the East Fork of the San Jacinto River to the west, SH 105 to the north, and FM 1960 to the south.

The RSA for Alternative 4 (**Figure 5-7**) includes pine-hardwood forests, crops, and willow oak-water oak-blackgum forest (TPWD's *The Vegetation Types of Texas*, Gould 1976) vegetation types, and is within the lower Trinity River Basin and includes Luce Bayou, Tarkington Bayou, Lake Houston, and the East Fork of the San Jacinto River. This RSA can be defined as being bordered by the Trinity River to the east, Lake Houston and the San Jacinto River to the west, FM 1960 to the north, and IH 10 to the south.

The RSA for Alternative 6 (**Figure 5-8**) includes pine-hardwood forests, crops, and willow oak-water oak-blackgum forest (TPWD's *The Vegetation Types of Texas*, Gould 1976) vegetation types, and is within the lower Trinity River Basin and includes Cedar Bayou, Lake Houston, and the lower Trinity River. This RSA can be defined as being bordered by the Trinity River to the east, Lake Houston and the San Jacinto River to the west, SH 105 to the north, and US 59/FM 1960 to the south.

### 5.2.3.2 Current Health and Historical Context Summary

#### 5.2.3.2.1 Vegetation

The vegetation/wildlife habitat land cover in the RSA is predominantly includes forested land and agricultural/ pastureland. Almost all forests in East Texas were logged by 1900, including those in the RSA. The upland forests present in the RSA have typically been managed for saw timber and pulpwood, and numerous harvests have occurred on the upland forests within the RSA. The bottomland forests have not been subject to the timber harvesting frequency the upland forests have. The bottomland forests are typically more difficult to log due to wet conditions. Based on site visits to the region and aerial photography, numerous large tracts with high quality bottomland forests exist within the RSA. Some areas have been converted to residential land uses; thus, losing vegetation and wildlife habitat. Numerous small disturbances such as pipelines, utility lines, oil/gas wells, and roads have occurred in RSA's undeveloped portions.

The structure and function of vegetation of Cedar Bayou's humid riparian are dominated by overland flows. Large, complex floodplains develop and include a large percentage of wetlands by area. Riparian vegetation varies by type, size and distribution and the distribution patterns of riparian vegetation depend on moisture gradients (flooding and depth to groundwater), fluvial geomorphic landforms, and stream gradients. Riparian corridors provide critical wildlife habitat in many landscape settings. Riparian vegetation provides support for many wildlife requirements. The value of riparian areas of Cedar Bayou are related to their size and contiguity and are most valuable when they remain intact and form a continuous corridor for wildlife migration. Intact riparian vegetation areas are most valuable and provide significant ecosystem benefit. Riparian vegetation affects the hydraulic and hydrologic functions of streams and rivers through bank stabilization and reduction of water loss from evapotranspiration. Flood attenuation is also increased in vegetated riparian systems in areas with maintained stream morphology through vegetative anchoring.

Due to its importance providing remaining riparian vegetation and habitat, at its confluence with Galveston Bay, Cedar Bayou is a critical wildlife habitat (TPWD 2010). Due to its importance to the Galveston Bay system fisheries and other wildlife resources, and to concerns about its listing as an impaired stream (303(d)), the Houston-Galveston Area Council (HGAC) applied for and received a Section 319(h) grant from EPA to prepare a watershed protection plan for the Cedar Bayou watershed (HGAC 2011). HGAC has been working with local stakeholders to systematically study the watershed and develop a watershed protection plan.

#### 5.2.3.2.2 Wildlife Habitat

The project area within Liberty and Harris counties is situated within the Austroriparian Biotic Province, which stretches from the Pineywoods in eastern Texas through the southeastern United States east to the Atlantic Ocean. In Texas, at least 47 mammal species, 29 snakes, 2 land turtles, 10 lizards, and 35 amphibians are known to exist within this province. According to Blair (1950), the Austroriparian Biotic Province supports more species of urodeles (salamanders and newts) than other biotic province in the state, with at least 18 species having occurred in recent times. The lower Trinity River basin supports a broad diversity of fish and aquatic species.

Various wildlife populations such as small birds and mammals, amphibians, and reptiles are under pressure from land conversion, development, and anthropogenic activities near FM 1960 in the Alternative 3A RSA. Similarly, some areas near IH 10 in the Alternatives 4 and 6 RSA are also developed. These activities have fragmented wildlife habitat and created barriers that impede wildlife movements. This confines wildlife to these fragmented riparian corridors, wetlands, and other areas where suitable habitat may be present. The habitat varies from open agricultural/pastureland to forested areas. Some impacts to wildlife habitat have occurred from planting monoculture pine forests, which are managed for timber. Often, these pine plantations reduce vegetation and wildlife species diversity. Within the RSA, wildlife populations are restricted in areas where there may be undeveloped land or riparian corridors in which to forage and seek shelter.

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One reason why Alternative 6 affects few wetlands and riparian vegetation within the Cedar Bayou corridor is because these areas have systematically been destroyed due to past actions and therefore no longer exist to be affected. As a result, the aquatic resource acreage to be traversed by Alternative 6 represents a measurable portion of the remaining forest resources in this part of Cedar Bayou. Due to the historic loss of these resources, Cedar Bayou’s remaining natural areas are under scientific study in light of this watershed’s ecological contribution to upper Galveston Bay and the potential for restoring instream aquatic life to sustainable levels (HGAC 2012). Further development in this watershed at this location would likely contribute to the cumulative adverse impacts already affecting Cedar Bayou.

### 5.2.3.3 Direct Effects Summary

#### 5.2.3.3.1 Vegetation

As discussed in **Chapter 2** and shown in **Table 2-2,** it was determined mesic forest, mesic grasslands and wetter vegetation types would be important vegetation types for protecting the physical, chemical or biological health for wetlands and other waters of the U.S., including wetlands within each alternative. Even though all the aquatic resources within each vegetation type may not meet waters of the U.S., including wetlands jurisdictional criteria, it is assumed wetter vegetation would have more than a minimum role in protecting wetlands and drier vegetation would have a lesser role. **Table 2-2** lists important vegetation types by alternative.

#### 5.2.3.3.2 Wildlife Habitat

The most significant sources for potential impacts to wildlife resulting from the proposed project would be habitat loss, habitat fragmentation and possible population separation in forested, scrub/shrub and herbaceous areas where vegetation would be removed. The proposed project may result in a barrier between wildlife populations that prefer these historically uninterrupted areas.

The intake structure causes the primary impact to aquatic wildlife. Fish and mussels may be impinged or entrained against the screens and within the pump bays during operation. Some species could potentially be impacted during construction activities such as dewatering. Construction impacts would be short-term and limited to the project footprint. The canal would provide additional aquatic habitat once in operation.

### 5.2.3.4 Indirect Effects Summary

#### 5.2.3.4.1 Vegetation

The proposed project is not expected to induce development. Adjacent property owners would not have access to water in the proposed canal. SHECO would provide the power needed to operate the CRPS. The alignment for the proposed electrical transmission line to provide service to the CRPS property is under evaluation and would be identified by the Public Utilities Commission. Alternative analyses are underway to evaluate a minimum of three alignment alternatives for the electrical transmission line. Based on these preliminary analyses, a maximum of 160 acres of forestland resources may be affected. However, the alternative alignment selected by the Public Utilities Commission for authorization and permitting would minimize impact to the natural environmental to the extent possible in compliance with environmental laws, rules, and regulations. As such, this acreage estimate represents the potential maximum impact. No other indirect impacts are anticipated to vegetation.

#### 5.2.3.4.2 Wildlife Habitat

Changes in wildlife habitat would occur due to the proposed project. Habitat loss, habitat fragmentation and possible population separation could result in forced displacement for native wildlife species. Creating additional fragmented habitat on the landscape could indirectly impact the local wildlife. Forest preferring species may be lost due to traffic accidents while trying to cross the barriers provided by the project. Clearing forested land for the SHECO's proposed electrical line could impact a maximum of 160 acres of forested land, thus fragmenting wildlife habitat. The alignment for the proposed electrical transmission line to provide service to the Capers Ridge Pump Station property is under evaluation and would be identified by the Public Utilities Commission. No other indirect impacts are anticipated to wildlife habitat related to potential habitat fragmentation.

### 5.2.3.5 Other Reasonably Foreseeable Effects

As development reaches into rural areas, many forests, if not fragmented or obliterated outright, are enveloped by human settlement (Friesen, Eagles & Mackay, 1995). This has imposed great stress on avian populations, with many songbird species experiencing declines in some portion of their range (Wilcove & Terborgh, 1984; Askins, Philbrick & Sugeno, 1990; Sauer, Hines & Fallon, 2005). As breeding habitat becomes more fragmented, nest predation increases (Gates & Gysel, 1978; King, Griffin & DeGraaf, 1996; Bayne & Hobson, 1997), brood parasitism increases (Brittingham & Temple, 1983), interspecific competition for resources is more pronounced (Cawthorne & Merchant, 1980; Ambuel & Temple, 1983), and pairing success decreases (Gibbs & Faaborg, 1990; Villard, Martin & Drummond, 1993).

Urbanization's effects on bird communities are well documented (Hoover, Brittingham & Goodrich, 1995; Friesen et al., 1995; Blair, 1996; Morse & Robinson, 1998; Porneluzi & Faaborg, 1999). These studies show total and native species richness declines at high development levels. Individual species; however, display differing responses to urbanization. Some birds reach peak densities in urban or suburban settings, while others reach peak densities at natural sites (Mills, Dunning & Bates, 1989; Blair, 1996; Clergeau, Savard, Mennechez & Falardeau, 1998; Gering & Blair 1999).

Individual specie's cumulative response to urbanization also results in changes at the bird assemblage level. Blair (2001) examined the distribution and abundance of birds along an urban gradient in southwestern Ohio. This study included a spectrum of habitat types created by urbanization, ranging from a pristine nature reserve to a highly developed urban center. Individual species displayed abundance patterns along the gradient that reflect their tolerance level for human impact. For example, European starlings (*Sturnus vulgaris*) were labeled "urban exploiters," based on their higher abundance at the gradient's urban end. On the opposite end, ovenbirds (*Seiurus aurocapilla*) were labeled "urban avoiders" based on their high abundance at the gradient's natural end and their complete absence from the urban end.

The urban bird community is most strongly influenced by vegetation, with the volume of native vegetation being most closely correlated with native bird density and species richness (Mills, Dunning & Bates, 1991). The urban environment favors species which can use small, discontinuous vegetation patches (Beissinger & Osborne, 1982). Urban exploiter densities are strongly correlated with lawn area and the volume of exotic vegetation (Mills, Dunning & Bates, 1989). The relationship between habitat variables such as vegetation density and species diversity has traditionally been explained in terms of food abundance and foraging niche space (MacArthur, 1961; MacArthur, MacArthur & Preer, 1962; MacArthur, Recher & Cody, 1966; Martin & Karr, 1986). However, Martin (1988b) hypothesized species distribution may also be influenced by the availability of suitable nesting sites.

Nest predators are the most common cause of nesting failure among open-cup nesting perching songbirds (Ricklefs, 1969; Martin, 1988a). As a result, pressure from predators may be an important factor in regulating bird densities and distributions (Emlen, 1974). The influence from nest predators at the group level has been largely unstudied (Martin, 1988c). Because the intensity of nest predators varies with the nest's materials and height (Ricklefs, 1969; Martin & Roper, 1988; Martin & Li, 1992; Martin, 1993a), the effects of vegetation on species distributions may be due in part to the availability of suitable nesting sites (Martin 1988c).

Many researchers have studied the effects from grazing, clear cutting and other types of habitat alteration on nest predators (e.g., see Wilcove, 1985; Hoover et al., 1995; Bayne & Hobson, 1997; Ammon & Stacey, 1997; Zanette & Jenkins, 2000). Recently, ecologists have started investigating these effects in urban settings. Changes in the predator's groupings coinciding with increased urbanization (Tomialojc, 1970; Churcher & Lawton, 1987) would be expected to change predator pressure, which in turn may affect overall community structure.

### 5.2.3.6 Cumulative Effects Analysis (CEA) Results

#### 5.2.3.6.1 Vegetation

Construction for the proposed project is estimated to clear approximately 1,050 acres of undeveloped land. The proposed LBITP could indirectly impact up to a maximum of 160 acres of forested land (but potentially less). The proposed project's cumulative impact could potentially be up to 1,210 acres of undeveloped land converted to infrastructure use. The RSA is primarily undeveloped with its southern portion being under more development pressure. As land is developed, vegetation is eliminated by clearing and grading and is then replaced with landscaped areas and impervious surfaces. Development has steadily increased within the RSA. The Houston-Galveston area is expected to experience continued economic growth and land development for decades. The total acreage of TPWD sensitive habitat hypes within each planned, proposed or existing project footprint by Alternative RSA was calculated and summarized by **Tables 5-7, 5-8, and 5-9**.

**Table 5-7:**
**TPWD Land Cover intersecting RSA 3A and Future Projects Detailed**

| Project Name | Sensitive Habitat Type | Acres |
|---|---|---|
| ENSTOR Houston HUB Storage and Transportation Facility, LP | Chenier Plain: Live Oak Fringe Forest | 1.35 |
| ENSTOR Houston HUB Storage and Transportation Facility, LP | Gulf Coast: Coastal Prairie Pondshore | 8.89 |
| ***ENSTOR Houston HUB Storage and Transportation Facility, LP Subtotal*** | | ***10.24*** |
| Grand Parkway SH 99 | Chenier Plain: Mixed Live Oak / Deciduous Hardwood Fringe Forest | 8.06 |
| Grand Parkway SH 99 | Gulf Coast: Coastal Prairie Pondshore | 8.31 |

| Project Name | Sensitive Habitat Type | Acres |
|---|---|---|
| Grand Parkway SH 99 | Pineywoods: Hardwood Flatwoods | 16.69 |
| Grand Parkway SH 99 | Pineywoods: Longleaf or Loblolly Pine / Hardwood Flatwoods or Plantation | 6.73 |
| Grand Parkway SH 99 | Pineywoods: Longleaf or Loblolly Pine Flatwoods or Plantation | 47.32 |
| Grand Parkway SH 99 | Pineywoods: Small Stream and Riparian Temporarily Flooded Hardwood Forest | 2.81 |
| Grand Parkway SH 99 | Pineywoods: Small Stream and Riparian Temporarily Flooded Mixed Forest | 1.33 |
| ***Grand Parkway SH 99 Subtotal*** | | ***91.25*** |
| Texas Land Fund No. 6 | Chenier Plain: Mixed Live Oak / Deciduous Hardwood Fringe Forest | 9.84 |
| Texas Land Fund No. 6 | Gulf Coast: Coastal Prairie Pondshore | 0.38 |
| Texas Land Fund No. 6 | Pineywoods: Wet Hardwood Flatwoods | 0.19 |
| ***Texas Land Fund No. 6 Subtotal*** | | ***10.41*** |
| Bumstead Living Trust | Chenier Plain: Live Oak Fringe Forest | 1.75 |
| Bumstead Living Trust | Chenier Plain: Mixed Live Oak / Deciduous Hardwood Fringe Forest | 78.97 |
| ***Bumstead Living Trust Subtotal*** | | ***80.72*** |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Chenier Plain: Mixed Live Oak / Deciduous Hardwood Fringe Forest | 2.96 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Bottomland Baldcypress Swamp | 0.34 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Bottomland Seasonally Flooded Hardwood Forest | 0.45 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Bottomland Temporarily Flooded Hardwood Forest | 0.94 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Bottomland Temporarily Flooded Hardwood Forest | 0.94 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Hardwood Flatwoods | 19.10 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Longleaf or Loblolly Pine / Hardwood Flatwoods or Plantation | 16.84 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Longleaf or Loblolly Pine Flatwoods or Plantation | 47.57 |

| Project Name | Sensitive Habitat Type | Acres |
|---|---|---|
| ***SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge Subtotal*** | | ***89.14*** |
| **Specialized Habitat RSA total for all Reasonably Foreseeable projects** | | ***281.76*** |

## Table 5-8: TPWD Land Cover intersecting RSA 4 and Future Projects Detailed

| Project Name | Sensitive Habitat Type | Acres |
|---|---|---|
| ENSTOR Houston HUB Storage and Transportation Facility, LP | Chenier Plain: Live Oak Fringe Forest | 1.35 |
| ENSTOR Houston HUB Storage and Transportation Facility, LP | Gulf Coast: Coastal Prairie Pondshore | 8.89 |
| ***ENSTOR Houston HUB Storage and Transportation Facility, LP Subtotal*** | | ***10.24*** |
| Grand Parkway SH 99 | Chenier Plain: Live Oak Fringe Forest | 0.29 |
| Grand Parkway SH 99 | Chenier Plain: Mixed Live Oak / Deciduous Hardwood Fringe Forest | 8.06 |
| Grand Parkway SH 99 | Gulf Coast: Coastal Prairie Pondshore | 8.31 |
| Grand Parkway SH 99 | Pineywoods: Hardwood Flatwoods | 16.69 |
| Grand Parkway SH 99 | Pineywoods: Longleaf or Loblolly Pine / Hardwood Flatwoods or Plantation | 6.73 |
| Grand Parkway SH 99 | Pineywoods: Longleaf or Loblolly Pine Flatwoods or Plantation | 47.32 |
| Grand Parkway SH 99 | Pineywoods: Small Stream and Riparian Temporarily Flooded Hardwood Forest | 2.81 |
| Grand Parkway SH 99 | Pineywoods: Small Stream and Riparian Temporarily Flooded Mixed Forest | 1.33 |
| ***Grand Parkway SH 99 Subtotal*** | | ***91.54*** |
| Texas Land Fund No. 6 | Chenier Plain: Mixed Live Oak / Deciduous Hardwood Fringe Forest | 9.84 |
| Texas Land Fund No. 6 | Gulf Coast: Coastal Prairie Pondshore | 0.38 |
| Texas Land Fund No. 6 | Pineywoods: Wet Hardwood Flatwoods | 0.19 |
| ***Texas Land Fund No. 6 Subtotal*** | | ***10.41*** |
| Bumstead Living Trust | Chenier Plain: Live Oak Fringe Forest | 1.75 |
| Bumstead Living Trust | Chenier Plain: Mixed Live Oak / Deciduous Hardwood Fringe Forest | 78.97 |
| ***Bumstead Living Trust Subtotal*** | | ***80.72*** |

| Project Name | Sensitive Habitat Type | Acres |
|---|---|---|
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Chenier Plain: Mixed Live Oak / Deciduous Hardwood Fringe Forest | 2.96 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Bottomland Baldcypress Swamp | 0.34 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Bottomland Seasonally Flooded Hardwood Forest | 0.45 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Bottomland Temporarily Flooded Hardwood Forest | 0.94 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Bottomland Temporarily Flooded Hardwood Forest | 0.94 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Hardwood Flatwoods | 19.10 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Longleaf or Loblolly Pine / Hardwood Flatwoods or Plantation | 16.84 |
| SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge | Pineywoods: Longleaf or Loblolly Pine Flatwoods or Plantation | 47.57 |
| ***SHECO Electrical Route from Tarkington Substation to Proposed Capers Ridge Subtotal*** | | ***89.14*** |
| **Specialized Habitat RSA total for all Reasonably Foreseeable projects** | | ***282.05*** |

**Table 5-9:**
**TPWD Land Cover intersecting RSA 6 and Future Projects Effects**

| Project Name | Sensitive Habitat | Acres |
|---|---|---|
| Keystone XL Project | Chenier Plain: Mixed Live Oak / Deciduous Hardwood Fringe Forest | 9.87 |
| Keystone XL Project | Gulf Coast: Coastal Prairie Pondshore | 60.32 |
| Keystone XL Project | Marsh | 1.92 |
| Keystone XL Project | Open Water | 4.66 |
| Keystone XL Project | Pineywoods: Bottomland Herbaceous Wetland | 0.39 |
| Keystone XL Project | Pineywoods: Bottomland Temporarily Flooded Hardwood Forest | 22.90 |
| Keystone XL Project | Pineywoods: Bottomland Temporarily Flooded Hardwood Forest | 22.90 |
| Keystone XL Project | Pineywoods: Bottomland Temporarily Flooded Mixed Pine / Hardwood Forest | 8.06 |
| Keystone XL Project | Pineywoods: Bottomland Wet Prairie | 0.24 |

| Project Name | Sensitive Habitat | Acres |
|---|---|---|
| Keystone XL Project | Pineywoods: Hardwood Flatwoods | 1.90 |
| Keystone XL Project | Pineywoods: Herbaceous Flatwoods Pond | 0.10 |
| Keystone XL Project | Pineywoods: Longleaf or Loblolly Pine / Hardwood Flatwoods or Plantation | 1.09 |
| Keystone XL Project | Pineywoods: Longleaf or Loblolly Pine Flatwoods or Plantation | 0.63 |
| Keystone XL Project | Pineywoods: Wet Hardwood Flatwoods | 5.00 |
| ***Keystone XL Project Subtotal*** | | ***139.99*** |
| Grand Parkway SH 99 | Chenier Plain: Live Oak Fringe Forest | 0.29 |
| Grand Parkway SH 99 | Gulf Coast: Coastal Prairie Pondshore | 22.99 |
| Grand Parkway SH 99 | Marsh | 4.60 |
| Grand Parkway SH 99 | Pineywoods: Wet Hardwood Flatwoods | 12.16 |
| ***Grand Parkway SH 99 Subtotal*** | | ***40.04*** |
| **Specialized Habitat RSA total for all Reasonably Foreseeable projects** | | ***180.03*** |

These impacts to sensitive habitat areas would be in addition to impacts of each alternative having a cumulative impact to sensitive habitats within the respective vegetation/wildlife RSA.

#### 5.2.3.6.2 Wildlife Habitat

Habitat loss, habitat fragmentation, and possible population separation could alter wildlife populations in the proposed project's vicinity. The proposed project would have direct and indirect effects by converting a maximum of 1,210 acres of undeveloped land to infrastructure use. Forced displacement and migration could occur due to difficulties circumventing barriers caused by the canal. The cumulative impact may include the continued changes to and potential decline in wildlife population numbers due to habitat fragmentation and potential population separation. Potentially displacing wildlife into adjacent habitats could increase competition for food and shelter for some resident and migratory species. Development is expected to continue in the region, which could increase habitat fragmentation and habitat loss.

### 5.2.3.7 Mitigation Opportunities

#### 5.2.3.7.1 Vegetation

Mitigation is proposed as part of CWA acquiring the mitigation site and transferring this land to the USFWS’s TRNWR. The mitigation site was selected for use because it contains forested and emergent wetlands, upland woodlands, and vegetation and habitat similar to what would be impacted. Long-term preservation for the mitigation site is expected to be by transferring the property's title ownership and subsequent management by the USFWS.

#### 5.2.3.7.2 Wildlife Habitat

Steps would be taken to prevent wildlife bottlenecking close to roadways to minimize potential traffic incidents with wildlife. At eighteen sites along the proposed canal alignment would force water underground through a siphon structure to minimize potential hydrology changes. These about 200-foot wide siphon areas would provide wildlife crossings that would extend across the project ROW. The mitigation site would be regulated by the Trinity River Natural Wildlife Refuge. However, the proposed mitigation that is favorable to wildlife habitat would need to be balanced with the need to protect public drinking water supplies and the need for fencing and other security facilities that would also impeded wildlife mobility. Consideration may also be given to stop or limit hunting within the mitigation property in the best interest for conserving wildlife species and to minimize negative effects to local wildlife. Clearing the ROW would occur outside the migratory breeding season to minimize impacts to migratory birds.

## 5.2.4 Prime Farmlands Soils

### 5.2.4.1 Resource Study Area (RSA)

The farmlands resource category addresses prime farmland soils, though not all the areas with mapped soils are currently in agricultural use. The RSA for the CEA for farmlands is the same are for all alternatives. The RSA is shown on **Figure 5-5**, and encompasses more than 796,000 acres in Liberty and Harris Counties. The RSA boundary is generally US 59 to the west, IH 10 to the south, the Liberty County Line to the northeast (and extended south to IH 10), and SH 105 to the north. The area includes approximately 523,900 acres mapped by the NRCS as either prime farmland soils or prime if irrigated. Of those, approximately 197,000 acres (38 percent) were mapped as cultivated crops or hay pasture in 2001.

### 5.2.4.2 Current Health and Historical Context Summary

The 1991 FPPA was enacted by Congress to help minimize the extent to which federal programs contribute to the unnecessary conversion of farmland to nonagricultural uses. The 2003 *Texas Rural Lands* study found Texas leads all other states in rural farming and ranching lands lost. According to the study, “if the trend continues at the same rate for the next two decades, much more of the land in south, central, and east-central portions of the state will become fragmented”. The RSA primarily has undeveloped forests and some agricultural areas, with some interspersed residential areas. Overall several decades, large amounts of rural farmland in the Houston region have been converted to developed uses. Concerned about the loss of prime agricultural land in Texas, the State of Texas is pursuing conservation easements on land, to preserve farms and ranches. According to the *Houston Chronicle*, “Prime agricultural land is vanishing at a rapid rate across Texas. State officials estimate that more than 2 million acres of cropland were converted to other uses between 1997 and 2007”.(Houston Chronicle 2012a).Utilizing public funds provided by the Farm and Ranch Lands Protection Program, the State program, administered by the Texas General Land Office, has two agreements in place in the Houston-Galveston region – one in Brazoria County (700 acres) and one in northwest Harris County (1,600 acres). According to the *Houston Chronicle*, “Prime agricultural land is vanishing at a rapid rate across Texas. Easements on three farms in Brazoria and Matagorda Counties are currently being considered, with a combined 2,565 acres to be preserved (Houston Chronicle 2012b).

It would be expected that this conservation program would continue, possibly extending to Liberty County, if landowners were willing to allow conservation easements on their farmlands. Future land use projections by HGAC indicate that the Houston suburban areas would continue expanding outward, with areas in the RSA (Harris County, and Liberty County to a lesser extent) experiencing increased development.

### 5.2.4.3 Direct Effects Summary

#### 5.2.4.3.1 Alternative 3A

Direct permanent impact to 746 acres of prime farmland soils. Form AD-1006, the Farmland Conversion Impact Rating, was completed to calculate the potential direct permanent impacts to farmland soils. NRCS would need to concur with a no effect determination.

#### 5.2.4.3.2 Alternative 4

Direct permanent impact to 685 acres of prime farmland soils. Form AD-1006, the Farmland Conversion Impact Rating, was completed to calculate the potential direct permanent impacts to farmland soils. NRCS would need to concur with a no effect determination.

#### 5.2.4.3.3 Alternative 6

Direct permanent impact to 618 acres of prime farmland soils. Form AD-1006, the Farmland Conversion Impact Rating, was completed to calculate the potential direct permanent impacts to farmland soils. NRCS would need to concur with a no effect determination.

### 5.2.4.4 Indirect Effects Summary

#### 5.2.4.4.1 Alternative 3A

Indirect effects to prime farmland and soils could occur as the project is implemented although efforts have been made to minimize direct and indirect effects on agricultural activities, farmed areas, reservoirs, pumps, irrigation systems, access to fields, and contoured fields to the extent possible in order to minimize and control indirect or unintended effects to prime farmland soils.

#### 5.2.4.4.2 Alternative 4

No site-specific investigations or coordination occurred for Alternative 4, as such indirect effects to prime farmland soils are not anticipated at this level of investigation.

#### 5.2.4.4.3 Alternative 6

No site-specific investigations or coordination occurred for Alternative 6, as such indirect effects to prime farmland soils are not anticipated at this level of investigation.

### 5.2.4.5 Other Reasonably Foreseeable Effects

The known reasonably foreseeable projects listed in **Table 5-2** would impact prime farmlands in the RSA. As there is currently no regulation specifically prohibiting development of farmland, the preservation of farmland would be on a voluntary basis. Quantifying future impacts to farmlands in the RSA is shown below in **Table 5-10**.

### 5.4.1.6 Cumulative Effects Analysis (CEA) Results

Overall several decades, large amounts of rural farmland in the Houston region have been converted to developed uses. The proposed project would directly impact prime farmland in Harris and Liberty Counties. The amount that would be impacted varies by alternative (see **Section 5.4.1.3**). Other projects that are reasonably foreseeable would also impact prime farmland in the RSA and these results are summarized below. The total acreage of prime farmland within each planned, proposed or existing project footprint was calculated and summarized by **Table 5-10**. Coordination with the NRCS has not been initiated to verify potential impacts to prime farmlands for these existing, planned and reasonably foreseeable projects.

**Table 5-10:
Prime Farmland Impacts for Reasonably Foreseeable Projects
within the Prime Farmland RSA**

| Reasonably Foreseeable Projects | Prime Farmlands Impact by project* (acres) |
|---|---|
| Keystone XL Pipeline, Gulf Coast Project | 1,314 |
| ENSTOR Houston HUB Storage and Transportation facility | 644 |
| Grand Parkway SH 99 | 1,134 |
| Texas land Fund No. 6 (future residential development) | 422 |
| Bumstead Living Trust (possible residential development) | 387 |
| Northeast Water Purification Plant Expansion | 137 |
| SHECO Electrical Route for Tarkington Substation to the Proposed Capers Ridge pump station | 88 |
| **Total Acres of Additional Prime Farmland Impacts within the RSA** | **4,128** |

* Farmland impacts are estimated and not verified by the NRCS. Impacts are calculated by the portion of the projects located within the Farmland RSA. If unknown, to calculate acres impacted, the ROW width for linear pipeline, roadway, or utility line projects were assumed to be 300 feet.

##### 5.2.4.5.1 Alternative 3A

The estimated prime farmland cumulative impacts are 4,874 acres including impacts from Alternative 3A.

##### 5.2.4.5.2 Alternative 4

The estimated prime farmland cumulative impacts are 4,813 acres including impacts from Alternative 4.

##### 5.2.4.5.3 Alternative 6

The estimated prime farmland cumulative impacts are 4,746 acres including impacts from Alternative 6.

#### 5.2.4.6 Mitigation Opportunities

No mitigation is proposed to mitigate for the loss of prime farmland that would result from the proposed project. Mitigation or impact minimization efforts may occur for projects with Federal funding or approvals, as a result of the FPPA. As more rural lands are developed, or proposed for development, the State of Texas could seek to obtain additional conservation easements for farmland in Texas, including in the RSA.

### 5.2.5 Floodplains (and Hydrology)

#### 5.2.5.1 Resource Study Area (RSA)

The RSA for floodplains (and hydrology) is the same as the RSA that was developed for wetlands/waters of the United States for each alternative. Wetlands and waters of the United States within the project area are directly influenced by hydrology and are generally concentrated within the floodplains of streams, bayous, lakes, and rivers within the study area. The determination of the floodplain (and hydrology) resource study area conforms to the watershed approach discussed in **Section 5.2.2.1**. Over the past 10 to 15 years, agencies and local governments have moved toward managing water resources by using the watershed approach (EPA 2005). The Floodplains RSA for Alternative 3A is shown in **Figure 5-3** and the Floodplains RSA for Alternatives 4 and 6 is shown in **Figure 5-4**.

#### 5.2.5.2 Current Health and Historical Context Summary

Preliminary engineering and hydraulic studies were initiated to analyze historic Trinity River flows, and anticipate water surface elevation at the proposed CRPS for various flow rates. Several engineering reports were generated to analyze Alternative 3A and look at existing conditions of drainage in the area. Site-specific analyses for Alternatives 4 and 6 have not been conducted, although investigations would be conducted during preliminary and final design.

As discussed in **Chapter 2***,* Alternatives 3A, 4, and 6 all cross more than one watershed boundary (**Figures 5-3**, and **5-4**). All project cross the watershed boundary for Cedar Bayou. It has been determined that the Cedar Bayou watershed is the most sensitive due to impaired water quality and other issues, discussed in detail in **Chapter 2** and in the *Cedar Bayou Watershed Protection Plan*. Alternative 3A affects the least amount of floodplain with Cedar Bayou watershed. About half of the watershed is in Harris County and the other half in Liberty and Chambers counties. Cedar Bayou is a southward flowing stream originating in Liberty County and enters Galveston Bay approximately 60 miles from its headwaters. The watershed encompasses approximately 202 square miles, and Cedar Bayou is the primary surface water feature. As discussed on HCFCD website, a large floodplain exists in the upper and middle reaches of Cedar Bayou, which is currently more sparsely populated and mainly contains sparsely developed areas and agricultural land; therefore, flooding is more threatening to roads and agriculture. However, flooding along tributaries in urbanizing areas of the watershed is a concern (HCFCD 2012). Most of the streams and floodplains are environmentally sensitive due to saltwater marshes in the lower reaches and undeveloped natural channel reaches upstream of Baytown. The TPWD considers the area around the mouth of Cedar Bayou to be a critical wildlife habitat (HCFCD 2012).

#### 5.2.5.3 Direct Effects Summary

The Alternative 3A alignment would be almost entirely outside the mapped 100-year floodplain as designated by the National Floodplain Insurance Program (NFIP). The proposed project would be constructed within 54 acres of floodplain/floodways.

Alternative 3A would have minimal effect on natural riverine overflow, except in the most severe (infrequent) precipitation events. The area in the Lake Houston discharge vicinity is within the 100-year-mapped floodplain, but there would be no increase in the lateral extent of the mapped floodplain because overland flow would be conveyed along the canal and would not cross the canal alignment. This design feature allows overland flow to continue across the canal alignment at the siphon structures' surface expression. A more detailed explanation about the design issues and modeling results used to identify siphon locations proposed as mitigation for Alternative 3A is included in **Section 4.2.1.5**.

In some areas, the proposed canal would be elevated above ground level possibly causing the canal structure to impede natural overland and channelized flow drainage paths unless otherwise controlled. As mitigation, a series of siphons in conjunction with collector ditches and culverts would be constructed along Alternative 3A canal alignment.

All siphon crossings are located where the natural drainage tends to be the most concentrated to avoid impacting or changing the natural drainage pattern. Much of the drainage in the Alternative 3A canal area is generated through sheet flow or very shallow concentrated flow which would be intercepted by ditches paralleling the canal. After overland flow has been carried across the Alternative 3A alignment, it would flow to the parallel ditch along the canal's downstream side so there is a lateral continuance of the natural sheet flow pattern to the extent possible.

Changes in floodplains and floodplain values would not occur due to Alterative 3A's operation. Approximately 48 acres of floodplain occurs along the canal alignment and at the proposed discharge point along Lake Houston.

Of the 48 acres within the floodplain, approximately 45 acres occur along the canal alignment near Parcel 50 in a grassy field/pasture. Since the canal and sedimentation basin would be excavated features, constructing these features would not decrease floodplain storage. The approximately 3 acres of floodplain remaining within the proposed project ROW occur at the discharge point for Alternative 3A. The proposed culverts would be constructed underground; would be covered with earthen material; and would not decrease floodplain storage compared to baseline or increase the amount of impervious cover; therefore, runoff volumes would represent baseline conditions. Floodplain impacts caused by or related to Alternative 3A operations are not expected.

#### 5.2.5.3.1 Alternative 4

The proposed project would be constructed within 170 acres of floodplain/floodways. The majority of the pipeline would be constructed adjacent to an existing Houston Natural Gas Company (HNG) pipeline easement south of Capers Ridge extending southwesterly to a point south of FM 1960. The pipeline could be located adjacent to an existing Sunoco pipeline easement from FM1960 to Lake Houston.

The pipeline ROW would traverse multiple land uses and natural areas as follows.

- From Capers Ridge to SH 321, the approximate 8-mile long ROW would mainly traverse the heavily-wooded Trinity River floodplain.
- From SH 321 to FM 1960, the approximate 10-mile long ROW traverses farmland and scattered wetlands and wooded areas as the ROW enters the upper Cedar Bayou watershed.
- From FM 1960 to FM 2100, the approximate 3-mile ROW crosses the Cedar Bayou watershed. It is carried under Cedar Bayou itself in a deep tunnel and is then tunneled under a number of Cedar Bayou's western tributary streams.
- The pipelines would discharge into Lake Houston close to the lake bottom, and would be designed to prevent posing a hazard to recreational boat traffic.
- Constructing and operating either improved canal conveyances or pipelines effect the watershed including altered drainage patterns and introducing other pollutants due to pipeline ROW or canal O&M.

#### 5.2.5.3.2 Alternative 6

The proposed project would be constructed within 112 acres of floodplain/floodways. The pipeline would convey raw water in a pipeline extending approximately 21.6 miles adjacent to an existing ExxonMobil pipeline easement to FM 2100 and then northward to Foley Road and west directly to Lake Houston. About 114,200 feet of constructed improvements would be needed to develop this alternative into a conveyance facility

Limited development exists along the proposed conveyance route; however, development is occurring along FM 2100. Alternative 6 would traverse a variety of land uses.

- From TRPS, the pipeline would be aligned in a 300-foot ROW and traverse farmland and patches of wooded areas and tunneled under multiple streams. Between Hatchfield Road and Cedar Bayou's main stem, residential areas would have to be traversed and ROW identified for the pipelines.
- Cedar Bayou would be crossed in a tunnel section and then aligned to cross US 90 and then across farmland and residential areas to a canal just south of the dam at Lake Houston.

Constructing and operating either improved canal conveyances or pipelines effect the watershed including altered drainage patterns and introducing other pollutants due to pipeline ROW or canal O&M. Water quality and sediment impacts through floodplain hazard areas and related development are principal concerns for the ongoing study.

Alternatives in the Cedar Bayou watershed would have to incorporate measures to minimize effects to sediment deposition in the Cedar Bayou and ensure ROWs maintenance activity did not further contribute to degraded water quality by using pesticides, insecticides, fertilizers or other ROW and facility maintenance program features. Despite implementing such measures, the risk of detrimental or adverse permanent effects to the Cedar Bayou watershed and to the Cedar Bayou itself from the water supply conveyance system construction and O&M would remain a long-term concern.

### 5.2.5.4 Indirect Effects Summary

#### 5.2.5.4.1 Alternative 3A

Flood hazards and floodplain values of the Cedar Bayou watershed, 5 acres in extent, and within the downstream Luce Bayou watershed would also be directly impacted by the proposed project which may directly impact Lake Houston and indirectly Galveston Bay.

#### 5.2.5.4.2 Alternative 4

Flood hazards and floodplain values of the Cedar Bayou watershed would also be directly and negatively impacted by the proposed installation of the Alternative 4 pipeline which would also indirectly affect Galveston Bay.

#### 5.2.5.4.3 Alternative 6

Flood hazards and floodplain values of the Cedar Bayou watershed would also be directly and negatively impacted by the proposed installation of the Alternative 6 pipeline which would also indirectly affect Galveston Bay.

### 5.2.5.5 Other Reasonably Foreseeable Effects

The known reasonably foreseeable projects listed in **Table 5-2** would impact floodplains in the Alternative 3A Floodplain RSA or Alternatives 4 and 6 Floodplain RSA. Regulations that protect floodplain resources would need to be followed for all proposed projects in accordance with requirements implemented by the local floodplain administrator. Future impacts to floodplains for floodplain hazard zones are summarized below (**Table 5-11**).

### 5.2.5.6 Cumulative Effects Analysis (CEA) Results

The build alternatives were evaluated according to the acres of floodway/floodplains they would traverse. FEMA's special flood hazard areas mapping was used for these acreage determinations. For all alternatives, it is presumed the project footprint would encompass the surface water conveyance canal and the subsurface pipelines within a 300-foot ROW and the proposed ROW would be developed to provide complete access at all times and during all conditions to the conveyance facilities or related facilities such as pump stations, flow meters, or booster pumps. This means access roadways and areas adjacent to canals or areas over pipelines would be elevated above the 100-year floodplain hazard area. **Figures 2-19** and **2-20** show the floodplains/floodway zones and acres traversed by the proposed alternatives. **Figures 2-21** through **2-25** compare the floodplain/floodway hazard zones in which each alternative would be located.

**Table 5-11:**
**Floodplain/Floodway Effects by Alternative**

| Reasonably Foreseeable Projects | Alternative 3A<br><br>Floodplain/Floodway Impacts by project*<br><br>(acres) | Alternatives 4 and 6<br><br>Floodplain/Floodway Impacts by project*<br><br>(acres) |
|---|---|---|
| Keystone XL Pipeline, Gulf Coast Project | 287 | 345 |
| Grand Parkway SH 99 | 269 | 124 |
| Texas land Fund No. 6 (future residential development) | 82 | 83 |
| Bumstead Living Trust (future residential development) | 192 | 129 |
| SHECO Electrical Route for Tarkington Substation to the Proposed Capers Ridge pump station | 30 | NA |
| **Total Acres of Additional Floodplain/Floodway Impacts within the RSA** | 1,022 | 681 |

* These are estimated impacts to reasonable foreseeable projects. Impacts are only estimated for portion of the projects located with the Wetlands/Floodplain RSAs. If there was an unknown project width for a linear project, it was assumed to be 300-ft wide.

#### 5.2.5.6.1 Alternative 3A

The estimated floodplain cumulative impacts is 1,076 acres including impacts from Alternative 3A. It is important to note that the USFWS NWR Proposed Acquisition of Floodplains for wildlife preservation purposes will preserve approximately 78,220 acres of floodplains/floodway within the Wetlands/Water of U.S. RSA for Alternative 3A.

#### 5.2.5.6.2 Alternative 4

The estimated floodplain cumulative impacts is 851 acres including impacts from Alternative 4. It is important to note that the USFWS NWR Proposed Acquisition of Floodplains for wildlife preservation purposes will preserve approximately 78,220 acres of floodplains/floodway within the Wetlands/Water of U.S. RSA for Alternatives 4 and 6.

#### 5.2.5.6.3 Alternative 6

The estimated floodplain cumulative impacts is 793 acres including impacts from Alternative 6. It is important to note that the USFWS NWR Proposed Acquisition of Floodplains for wildlife preservation purposes will preserve approximately 78,220 acres of floodplains/floodway within the Wetlands/Water of U.S. RSA for Alternatives 4 and 6.

### 5.2.5.7 Mitigation Opportunities

#### 5.2.5.7.1 Alternative 3A

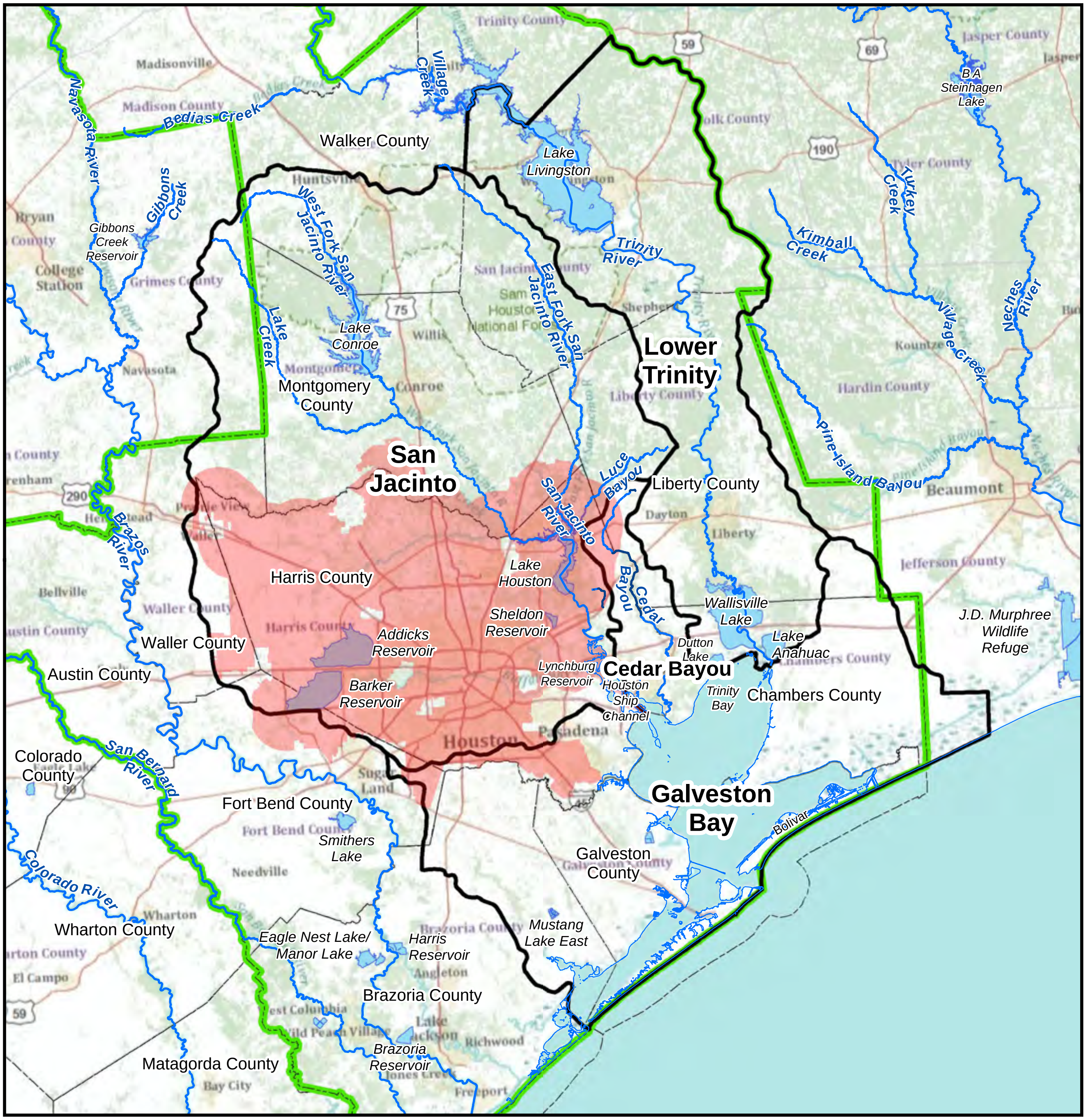
As discussed above, siphon structures would eliminate hydrology changes and provide opportunities for safe wildlife crossings. In some areas, the proposed Alternative 3A canal would be elevated above ground level possibly causing the canal structure to impede natural drainage paths of overland and channelized flow unless otherwise controlled. The general design approach for the Alternative 3A siphon structures for handling overland sheet flow includes surface water flow being conveyed across the canal alignment in areas outside the identified watershed divides. A few typical locations were modeled to provide results needed for siphon design. As mitigation, a series of siphons in conjunction with collector ditches and culverts would be constructed along the Alternative 3A canal alignment ROW. Avoidance of floodplains, including the Cedar Bayou floodplain and flood hazard areas should occur.

#### 5.2.5.7.2 Alternative 4

Mitigating these would require detailed management plans and consistent plan enforcement. Generally, any conveyance alternative traversing the watershed would have the potential to adversely affect the watershed’s physical, chemical, and biological health. Alternatives using the existing canal system could have a lesser impact on the watershed. However, necessary improvements to the system as described earlier and the likelihood new canal alignments would be required to avoid wetlands reduces the feasibility to extensively use the existing canal system without major changes.

#### 5.2.5.7.3 Alternative 6

Mitigating these would require detailed management plans and consistent plan enforcement. Generally, any conveyance alternative traversing the watershed would have the potential to adversely affect the watershed’s physical, chemical, and biological health. Alternatives using the existing canal system could have a lesser impact on the watershed. However, necessary improvements to the system as described earlier and the likelihood new canal alignments would be required to avoid wetlands reduces the feasibility to extensively use the existing canal system without major changes.




Base from ESRI Online accessed December 2011;
Existing and recommended reservoirs from TWDB.

- City of Houston City Limits & ETJ
- Region H
- Watershed Boundary
- Existing Reservoirs
- County Boundary

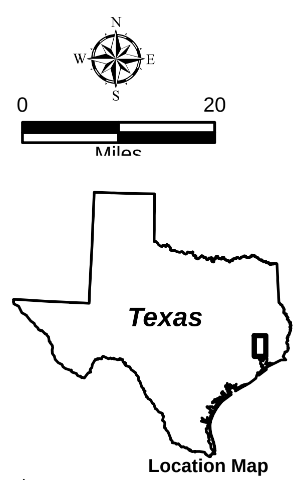



**Figure 5-1 : Regional Water Resources by Watershed**

**Luce Bayou Interbasin Transfer Project**

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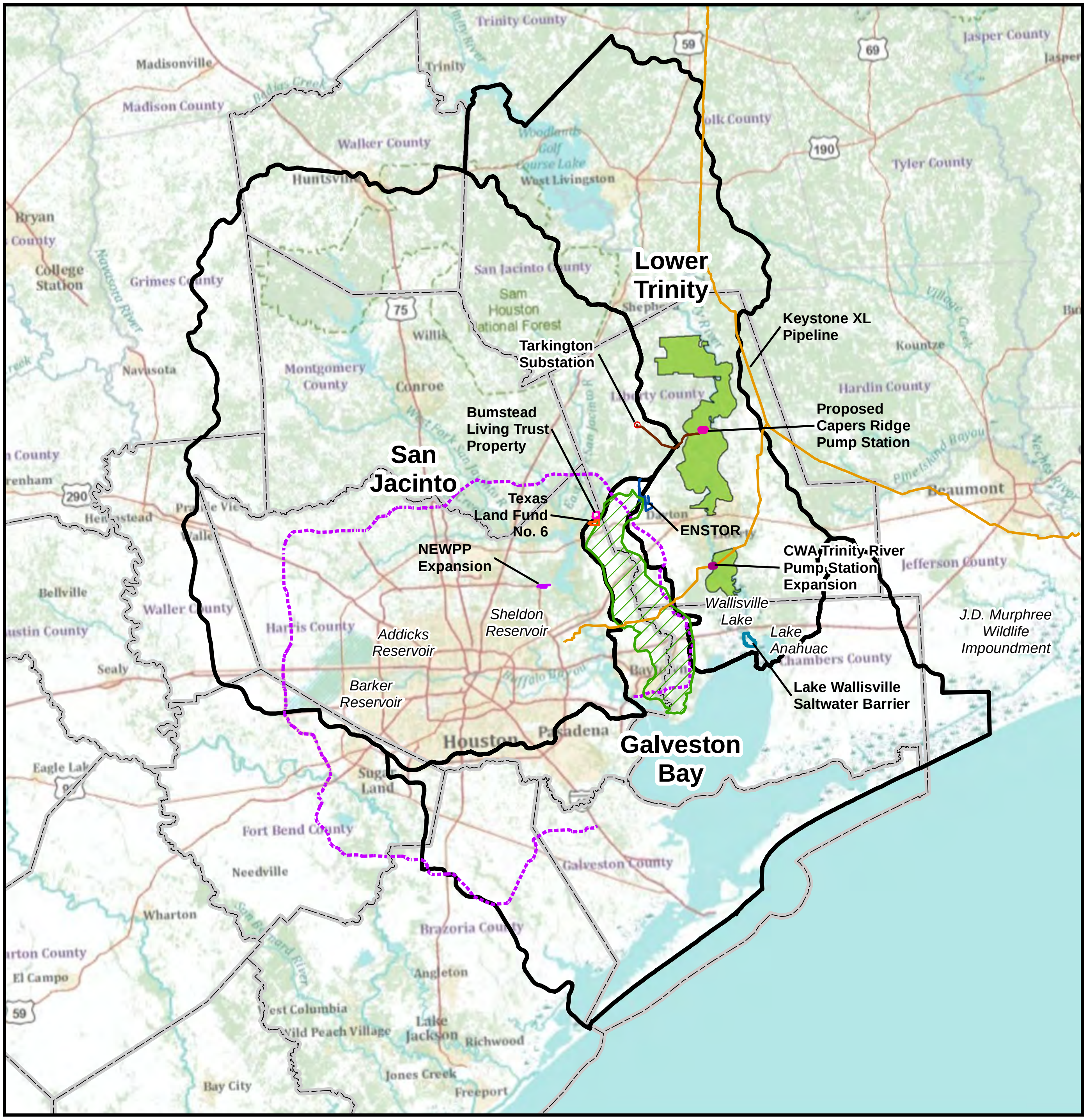


Base from ESRI Online accessed December 2011

County Boundary
Watershed Boundary

**Future Projects**

Keystone XL Pipeline Project
Proposed Grand Parkway (State Highway 99)
SHECO Electrical Power Distribution System
Texas Land Fund No 6 Property
Bumstead Living Trust Property
ENSTOR Houston HUB Storage and Transportation Facility
CWA Trinity River Pump Station Expansion
Northeast Water Purification Plant (NEWPP) Expansion
Cedar Bayou Watershed Protection Plan
USFWS Proposed Acquisition Boundary
Lake Wallisville Saltwater Barrier

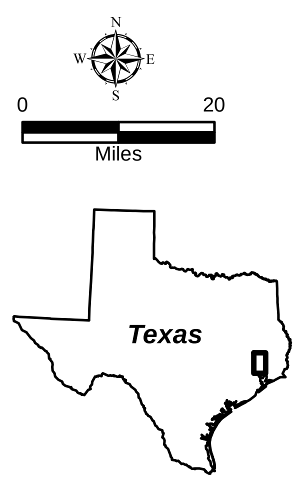


**Figure 5-2 : Projects Identified for Cumulative Effects Analysis (CEA)**

**Luce Bayou Interbasin Transfer Project**

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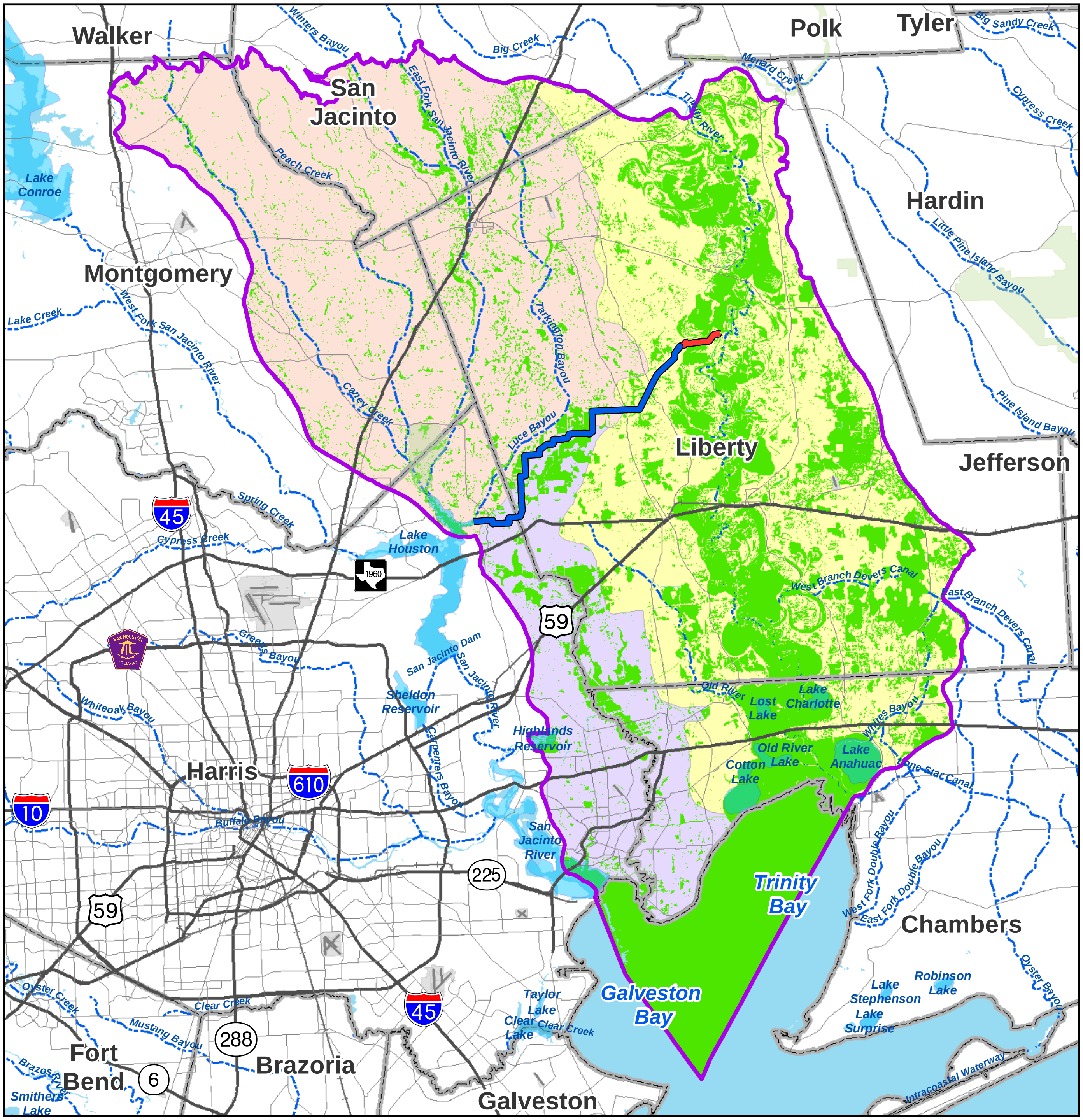


Source:
Waters of the U.S.: Houston-Galveston Area Council
National Land Cover Database 2001 (NLCD 2001), USGS
National Wetlands Inventory: USFWS (April 1, 2012)
http://www.mrlc.gov/nlcd_multizone_map.php
Basemap Source: ESRI 2008 StreetMap data.

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## Legend

- Alternative 3A Canal
- Alternative 3A Pipeline
- Resource Study Area
- National Wetlands Inventory
- County Boundary
- East Fork San Jacinto Watershed
- Lower Trinity Watershed
- North Galveston - Cedar Bayou Watershed

**Waters of the U.S.**
- Streams, Rivers
- Bays, Lakes, Reservoirs

Location Map

**Figure 5-3: Alternative 3A Waters of the U.S. / Wetlands Resource Study Area**

**Luce Bayou Interbasin Transfer Project**

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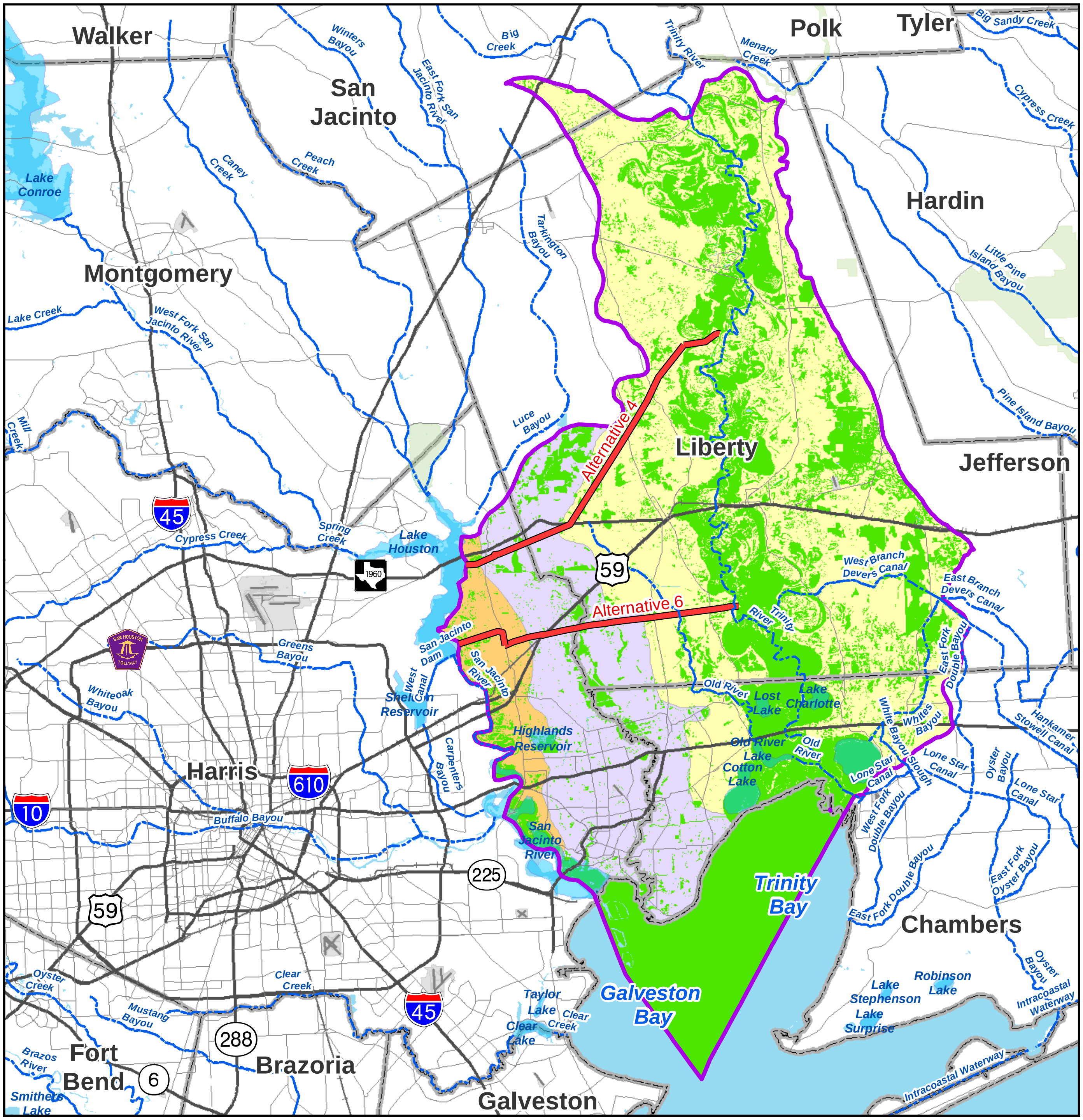


Source:
Waters of the U.S.: Houston-Galveston Area Council
National Wetlands Inventory: USFWS (April 1, 2012)
http://www.mrlc.gov/nlcd_multizone_map.php
Basemap Source: ESRI 2008 StreetMap data.

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## Legend

- Alternative Pipelines
- Resource Study Area
- National Wetlands Inventory
- County Boundary
- Lower Trinity Watershed
- North Galveston - Cedar Bayou Watershed
- Buffalo-San Jacinto Watershed (portion)

**Waters of the U.S.**
- Streams, Rivers
- Bays, Lakes, Reservoirs


**Location Map**

**Figure 5-4: Alternatives 4 and 6 Waters of the U.S. / Wetlands Resource Study Area**

**Luce Bayou Interbasin Transfer Project**

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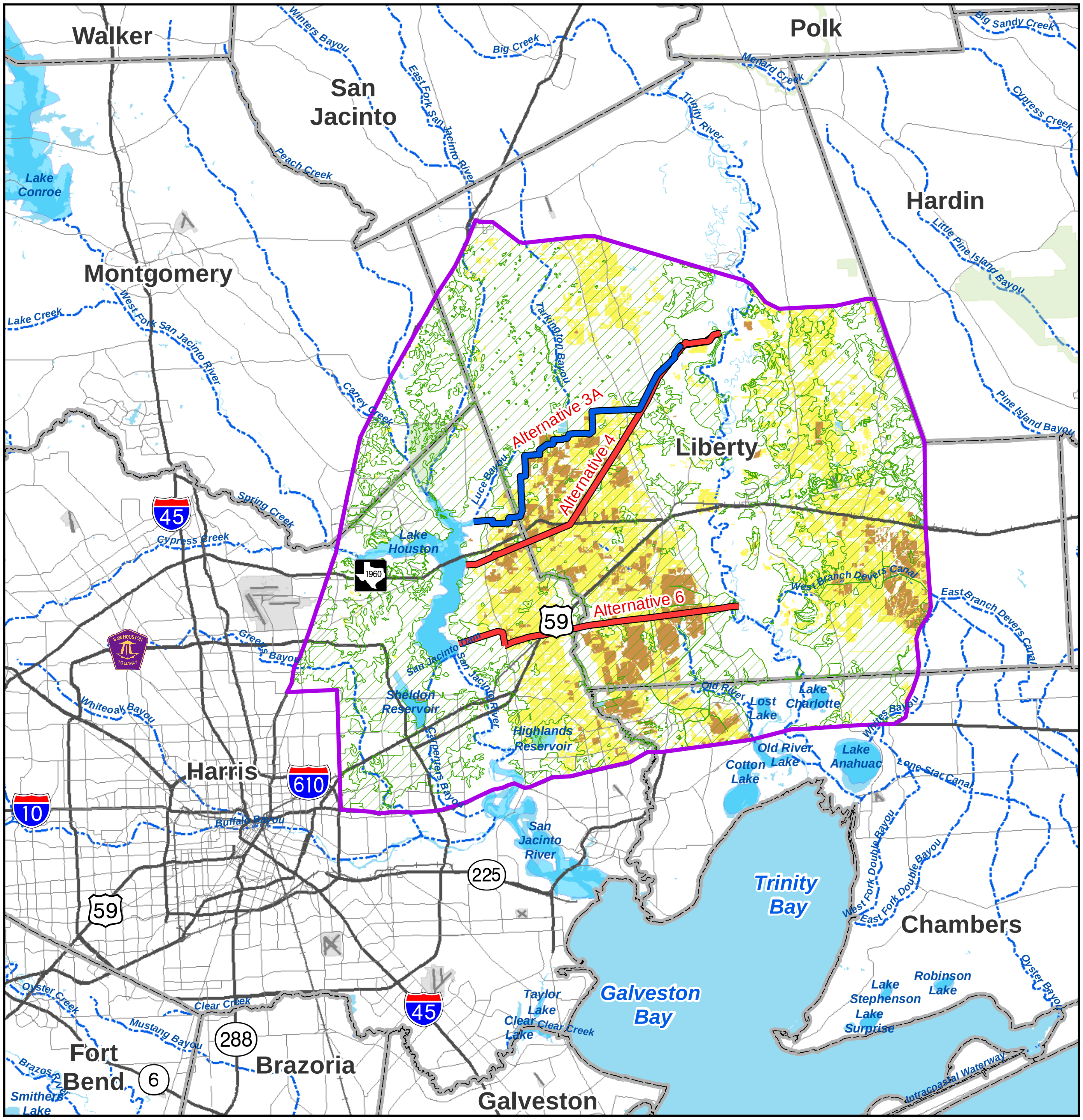


Source:
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National Land Cover Database 2001 (NLCD 2001), USGS
National Wetlands Inventory: USFWS (April 1, 2012)
http://www.mrlc.gov/nlcd_multizone_map.php
Basemap Source: ESRI 2008 StreetMap data.

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**Legend**

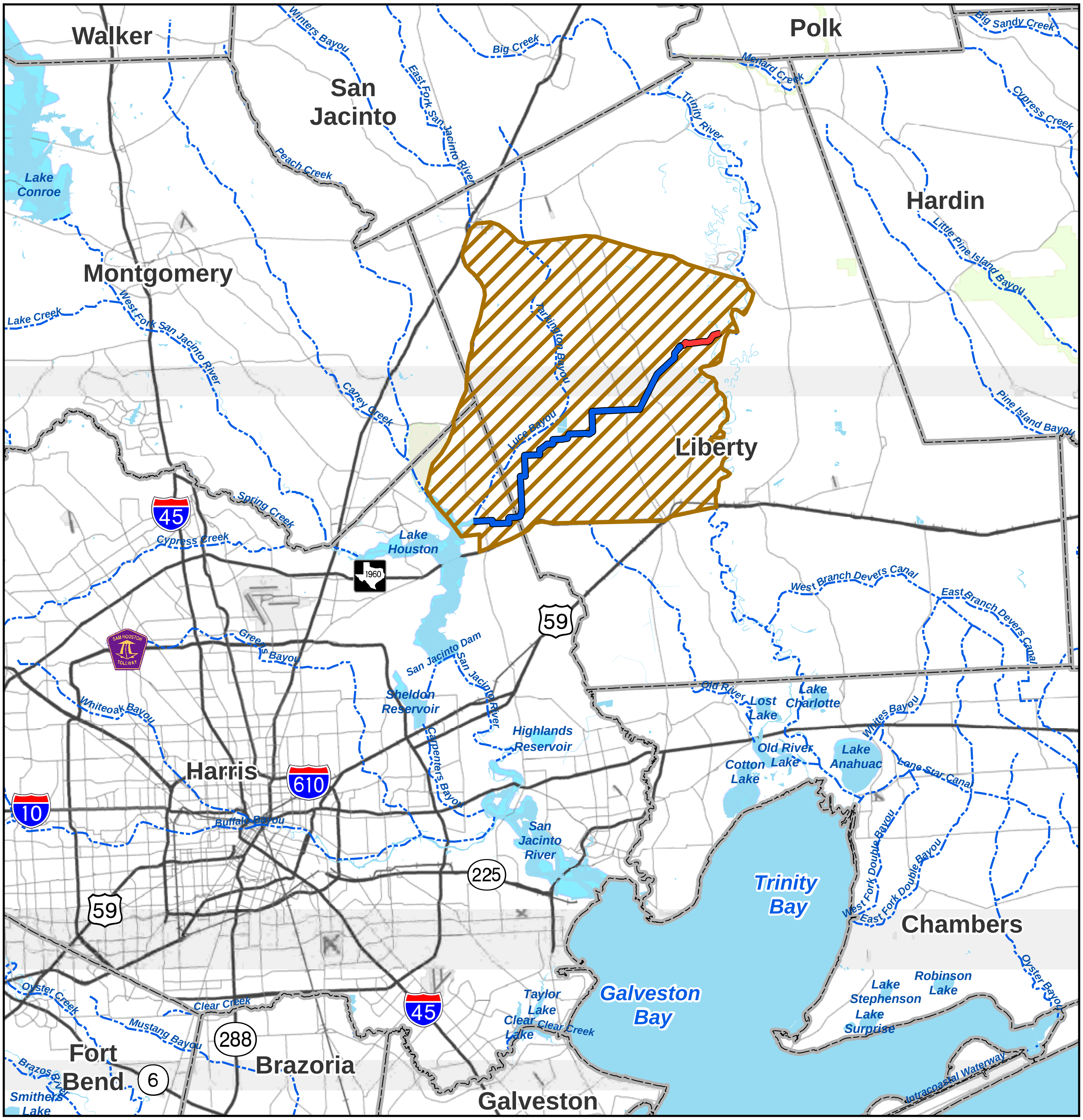
- Alternative Canal
- Alternative Pipeline
- Resource Study Area
- County Boundary
- Prime Farmland
- Pasture, Hay
- Cultivated Crops
- Streams, Rivers
- Bays, Lakes, Reservoirs


Location Map

**Figure 5-5: Prime Farmland Resource Study Area**

**Luce Bayou Interbasin Transfer Project**

Path: O:\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_5_Figures\Figure 5-5_PrimeFarmland_RSA_Alt3A-4-6.mxd




Source:
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National Land Cover Database 2001 (NLCD 2001), USGS
National Wetlands Inventory: USFWS (April 1, 2012)
http://www.mrlc.gov/nlcd_multizone_map.php
Basemap Source: ESRI 2008 StreetMap data.

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## Legend

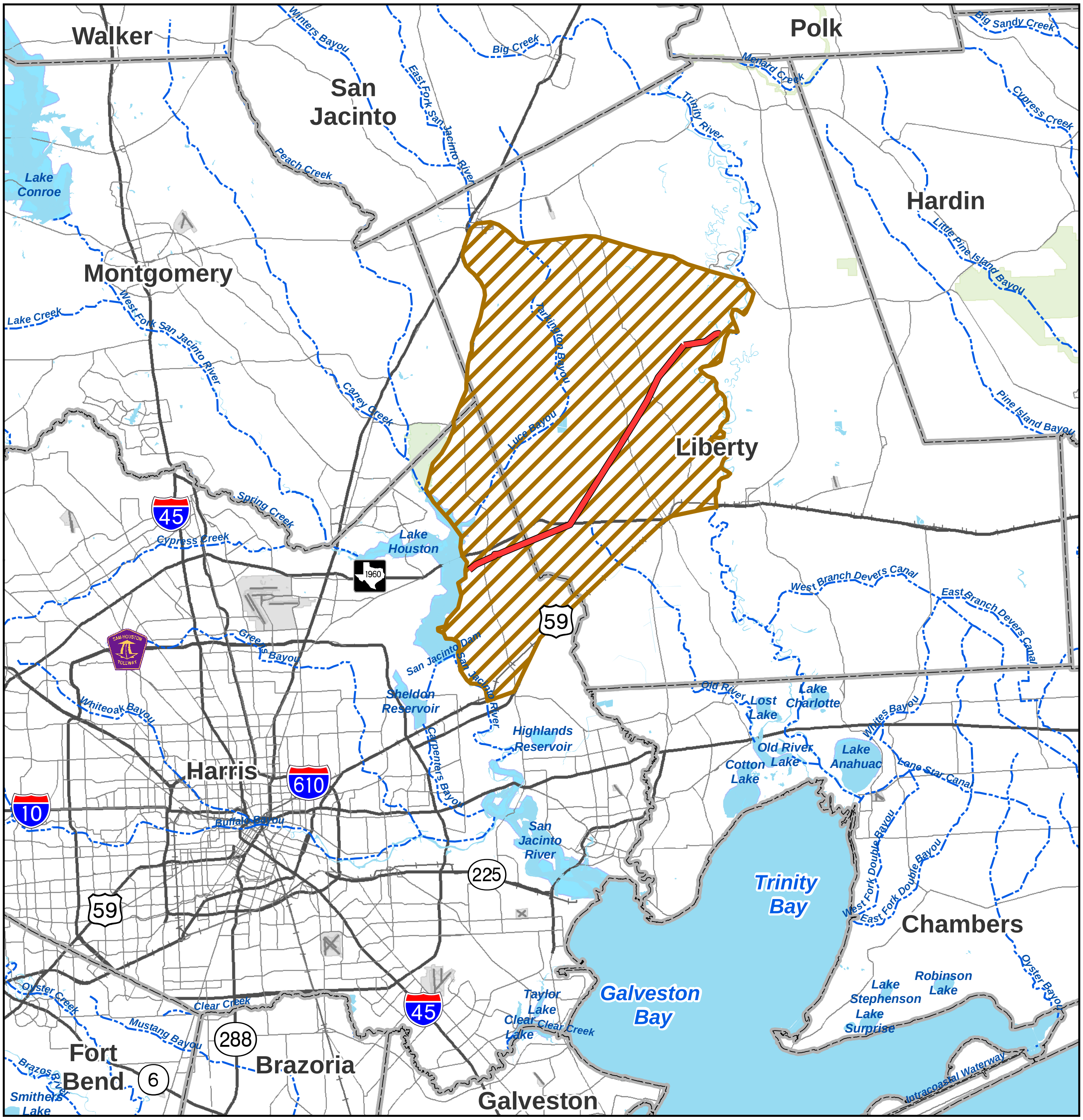
- Alternative 3A Canal
- Alternative 3A Pipeline
- Vegetation / Wildlife Resource Study Area
- County Boundary
- Streams, Rivers
- Bays, Lakes, Reservoirs


Location Map

**Figure 5-6: Alternative 3A Vegetation / Wildlife Resource Study Area**

**Luce Bayou Interbasin Transfer Project**

Path: O:\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_5_Figures\Figure 5-6_Vegetation_Wildlife_RSA_Alt3A.mxd




Source:
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National Land Cover Database 2001 (NLCD 2001), USGS
National Wetlands Inventory: USFWS (April 1, 2012)
http://www.mrlc.gov/nlcd_multizone_map.php
Basemap Source: ESRI 2008 StreetMap data.

**Legend**

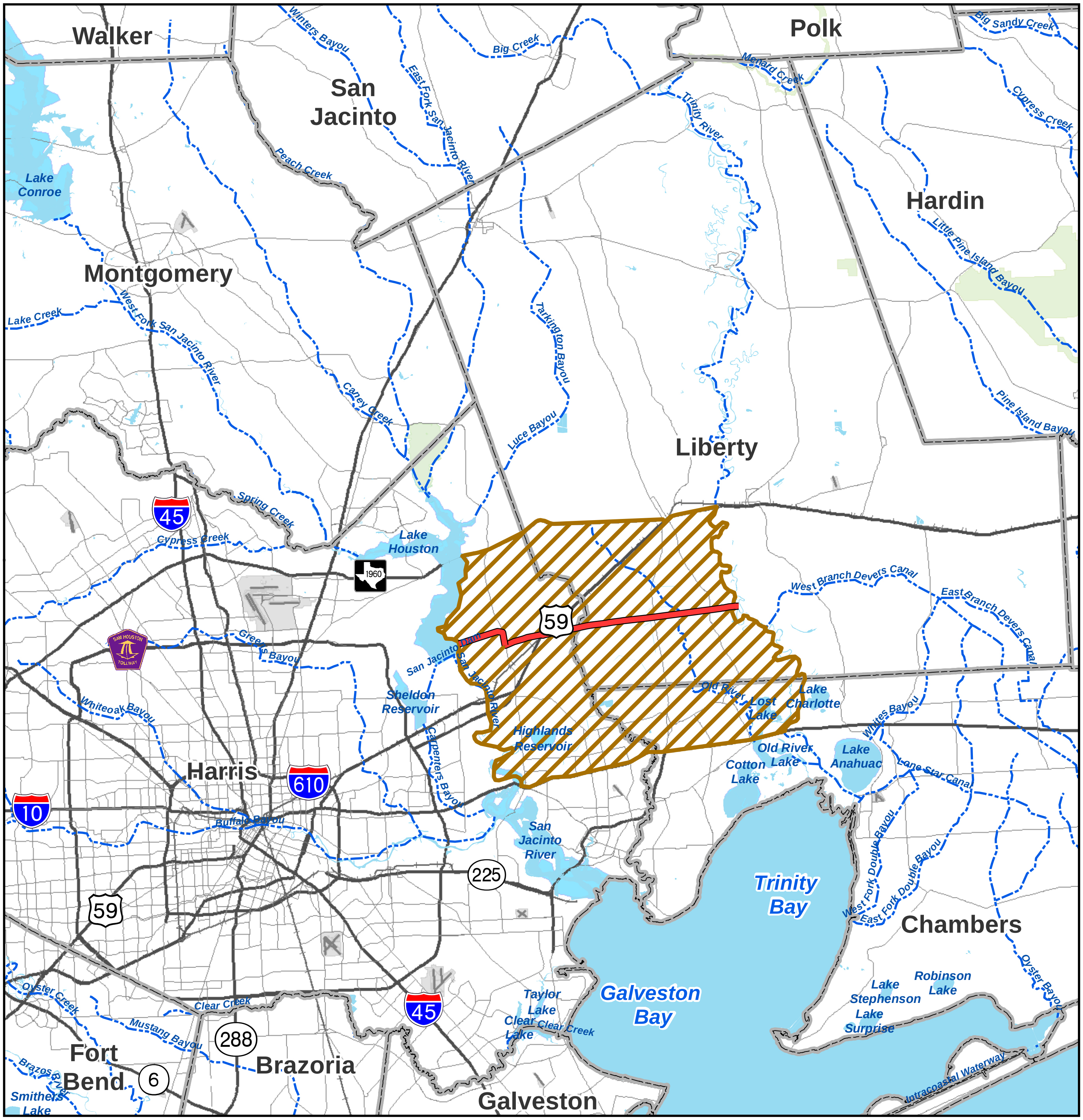
- Alternative 4 Pipeline
- Vegetation / Wildlife Resource Study Area
- County Boundary
- Streams, Rivers
- Bays, Lakes, Reservoirs


Location Map

**Figure 5-7: Alternative 4 Vegetation / Wildlife Resource Study Area**

**Luce Bayou Interbasin Transfer Project**

Path: O:\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_5_Figures\Figure 5-7_Vegetation_Wildlife_RSA_Alt4.mxd

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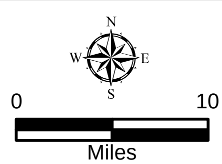


**Legend**

- Alternative 6 Pipeline
- Vegetation / Wildlife Resource Study Area
- County Boundary
- Streams, Rivers
- Bays, Lakes, Reservoirs


Location Map

**Figure 5-8: Vegetation / Wildlife Resource Study Area**

**Luce Bayou Interbasin Transfer Project**

Path: O:\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Section_5_Figures\Figure 5-8_Vegetation_Wildlife_RSA_Alt6.mxd

# 6 Means To Mitigate Environmental Effects

2012

US Army Corps
of Engineers
Galveston District

# Contents

**List of Tables**



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# 6.0 MEANS TO MITIGATE ENVIRONMENTAL EFFECTS

The means to mitigate for the proposed action's environmental consequences and for implementing the Luce Bayou Interbasin Transfer Project (LBITP) would be developed in accordance with state, federal, and local laws, regulations, ordinances, Executive Orders and permit provisions. Mitigation or management activities to be performed during LBITP's construction, operation, and maintenance may occur under permit or as required by other approvals or authorizations, all of which are covered in Chapter 4. The text following this list provides information on mitigation or management activities too detailed to be covered in the mitigation sections in Chapter 4.

## 6.1 Geological Elements

The greatest effect to geology within the regional study area has been calculated for all three action alternatives; based on this analysis, the greatest change or potential change related to geology would be expected to occur for Alternative 3A. Since this alternative includes the permanent construction of both below-ground pipeline and an open water, above-grade canal structures, as well as construction of the CRPS, potential effects of geology related to implementation of Alternative 3A would exceed those that would occur for Alternatives 4 and 6. This discussion regarding the reduction and mitigation of potential impacts focuses on the potential effects related to the construction and operation of Alternative 3A in order to provide the proper framework for understanding the range of possible mitigation strategies that may be effective or considered for implementation.

### 6.1.1 Subsidence

The effects to land subsidence evaluated in the Houston area from 1994 to 1999 led to adopting the Harris-Galveston Subsidence District (HGSD) 1999 Regulatory Plan. The areas already converted were not altered much. Four areas were combined into one large area labeled Area 3 in the 1999 Regulatory Plan. It was determined the average size and number of permittees, typically municipal utility districts, were not individually sufficient to economically convert from groundwater to surface water. In Areas 1 and 2, HGSD had dealt mainly with large entities such as Houston, Pasadena, Baytown, and Texas City, along with the large industries along the Houston Ship Channel. Those permittees were closer to surface-water sources and large enough to fund the necessary project to build the needed conversion infrastructure. In Area 3, with over 400 municipal utility districts and other smaller permittees, cooperation amongst the permittees was paramount.

The 1999 Regulatory Plan allowed Area 3 permittees to work together to collectively meet HGSD's mandated conversions from groundwater to alternative supplies. The 1999 Regulatory Plan revised the conversion schedule with the first mandated reduction in Area 3 set to occur in 2010 at 30 percent of the total water demand. Two more conversions will be necessary in 2020 and 2030 to achieve the ultimate goal for groundwater to constitute only 20 percent of total water demand in Area 3. With the projected 1999 Regulatory Plan's implementation, subsidence rates slowed dramatically from 2010 to 2020 and then halted from 2020 to 2030.

Water levels within the aquifer are predicted to rebound by as much as 125 feet with successful groundwater withdrawal reductions. The driving force behind the requirements in the 1999 Regulatory Plan was adopting a deterrent. The draw off from the river will depend on Lake Houston water levels, the amount of flow required to meet North East Water Purification Plant's raw water demands, and other demands associated with Lake Houston. Constraints on the upper water limit that can be supplied by the Capers Ridge Pump Station (CRPS) or the TRPS are determined by the limitations on Houston's water rights from the Trinity River Basin.

The number of pumps selected for CRPS and the existing TRPS was based on meeting these demands from the initial plant startup thru the gradual increase in demands until the year 2040. In conjunction with this is a daily goal to maintain a minimum flow and level in the canal, and to provide reliability in pumping operations. Due to the sediment laden water in the river, sediment will need to be removed from the raw water intake before reaching the pumps to:

- Protect them from excessive wear and failure;
- Prevent additional sediment from being transported to Lake Houston via the pipeline and canal; and
- Minimize sediment deposition in the canal which could reduce canal capacity.

### 6.1.2 Sedimentation and Erosion

The meandering Trinity River shows evidence of extensive flooding and erosion. The lower Trinity floodplain, in which the CRPS and the TRBS currently contains numerous oxbow lakes, meander scars, and other evidence the river is a dynamic, always migrating system. CRPS will be on the outside of a meander bend. Upstream from where the station will be located, the river's slope is steeper with a greater sediment transport capacity. However, the reach is also sediment starved due to Lake Livingston, which acts as a sediment trap. The river reach from just upstream to just downstream from CRPS has an overall lower slope providing a decreased sediment transport capacity and increased sediment storage.

Possible locations of meander migration, river realignment, and meander cutoff that would threaten integrity of the proposed intake were identified. While the Trinity River is an actively meandering river with numerous bends, the large meander bend located at point bar (PB) 9 (Figure 3.2) is of particular importance. This section has been identified previously as a likely candidate for meander cutoff as continued erosion of this bend would allow the Trinity River to cut a new river channel, circumventing the proposed intake location (Phillips, 2008a).

Due to the size of the Trinity River, excessive bank height, and scale of the meander at this point bar, typical bank protection practices alone would not suffice to protect this meander from further erosion. Consequently, in-channel hydraulic structures were also considered as alternatives to reduce the risk of meander cutoff at this location (Odgaard, 2009; USACE, 2005; Thorne, et. al., 1997). Recommended concepts for addressing instability of this bend are presented in Appendix K.

### 6.1.3 Hardened Banks at Intake Location

Concept drawings for the proposed intake were used to assess the potential extent of bank hardening. Geotechnical logs and bore records were provided by Fugro and used to conduct geotechnical analysis of the banks (Fugro, 2009). Elevation and survey data included LIDAR terrain data and multi-beam hydrographic survey data of the river that were provided by AECOM. Full details of the concept methods are provided in Appendix K. Of a number of potential scenarios considered, three have been selected as the most likely concepts to consider for full development. These are discussed in the results section.

In all three alternatives, stone gradations and layer thickness were conceptually designed using empirical methods outlined in the Coastal Engineering Manual (2006) and Engineering Manual 1110-2-1601 Hydraulic Design of Flood Control Channels (USACE 1994). Sheet pile walls were conceptually designed for short and long term loading conditions based upon analysis of water level records and provided soils and geotechnical information (Fugro, 2009).

The sediment's clay fraction is not considered in the bed load transport, since it remains in suspension as part of the wash load regardless of the flow rate. Silts, sands and gravels are part of the bed load that settles out. Then they are re-suspended into the water column and transported downstream, depending on the water velocity at any given location.

Under atypical low flow conditions, the CRPS and TRPS flow withdrawal would decrease sediment transport capacity downstream. This condition occurs when the withdrawal rate makes up a high percent of the total flow in the river. However, this decrease in transport capacity only affects very fine to fine sands, which are the most mobile sediments. This material will be easily remobilized and flushed through the river at the more typical flow conditions. At normal or high flood flows where the withdrawal rate is a very low percent of the total flow in the river, there is no effect on the river's transport capacity.

Low flow conditions could potentially cause slightly elevated suspended sediment concentrations downstream from CRPS, due to increased suspended sediment loading from compensating flows and the water withdrawal by CRPS. However, the difference in observed suspended sediment concentration is very small between 700 cfs (normal existing low flow conditions) and a 1,500 cfs flow (a low flow of 700 cfs with compensating flows), especially relative to the sediment amount in motion at higher flows.

CRPS is designed to remove primarily sand from the raw water at the intake structure. Several alternatives have been proposed concerning what to do with the sediment removed from the water.

- Reintroduce the removed sediment back into the river downstream from CRPS.
- Transfer the removed sediment to an onsite dewatering basin, dewater, and store on the CRPS site.
- Reintroduce sediment into the pipe line after the pumps to be conveyed by the pipeline to, and removed in a sedimentation pond at the end of the pipeline.
- Process the sediment slurry thru a solid-liquid separator, then haul to an offsite location or store onsite.

## 6.2 Hydrology

Trinity River flows vary from low flows during low rainfall periods and droughts to high flows during flooding events. Historical USGS flow records from the Trinity River for the past 83 years at the nearest upstream and downstream gage stations, the Romayor Station and the Liberty Station respectively, were used to establish baseline flows at the site. Based on these records, the flows range from about 600 cfs, as an annual low flow to as high as 130,000 cfs during extreme flood events, with a median or typical flow at about 6,000 cfs. The 600 cfs low flow occurs about once every two years.

The Lake Livingston Dam monitor operators' withdrawal rates form an existing pump station downstream and release extra water from the dam to maintain minimum low flows downstream from that pump station. TRA operators will also monitor CRPS or TRPS withdrawal rates and release additional flow as needed to meet water rights and maintain at least a minimum 600 to 800 cfs flow downstream from CRPS or TRPS.

During typical 6,000 cfs, flows in the river, the 293 MGD design draw off from CRPS or TRPS would amount to about 7 percent of the flow in the river without additional releases from the dam. At high flows in the river during flood events, the withdrawal rate would be an even lower percentage of the total river flow.

The proposed LBITP canal has side berms, access roads, and an anticipated 7-foot water depth. Eighteen siphon structures would convey LBITP water in the canal below the ground surface through concrete box culverts. These siphon structures would maintain local hydrologic and drainage systems to convey sheet flow overland. The surface expression for these drainage conveying siphons includes ditches, swales and open grassy areas. These siphon structures would not be located at pipeline, utility easements or roadway crossings, and would allow wildlife safe passage across the proposed 23.5-mile LBITP canal conveyance structure. The siphon structures would be covered with grass and would primarily be located at ground level with a small swale to allow for drainage across the canal right-of-way (ROW).

The canal alignment and siphon locations would be fenced with barb-wire along the LBITP ROW boundaries. The barb-wire fences would be designed to facilitate wildlife mobility across the LBITP, minimize entanglement risks and not restrict water flow. The siphons are proposed to be along the canal alignment in undeveloped areas at points determined by hydraulic analyses to require overland flow conveyance to avoid impacts to local hydrology. The proposed combination siphon and wildlife crossing features are to be along the 23.5 mile length of the proposed LBITP canal. Wildlife concerns and criteria for construction project fencing would be considered during the final LBITP design. Along the LBITP pipeline and at utility easements and roadway crossings located away from the siphon and wildlife crossing areas, minimum 6- to 8-foot high chain-link fences would be constructed for motorist and pedestrian safety. The chain-link fences would prevent wildlife from crossing the LBITP at roadways and would reduce wildlife mortality rates in these areas.

Wetlands bisected by the proposed canal and occurring inside and partially outside the LBITP ROW could potentially be impacted, although the proposed siphons have been designed to minimize and eliminate impacts related to changes in hydrology. Siphon conveyance for the LBITP canal in below-grade culverts was designed to provide hydrologic wetland resource connections to avoid degradation that may occur by constructing the canal. Precipitation is the major hydrology source for wetlands identified in the LBITP canal's vicinity. To minimize degradation that could occur from interrupting overland flow, 18 drainage crossings are proposed for the canal design to maintain hydrologic connection areas.

The proposed LBITP canal alignment is almost entirely outside the 100-year floodplain for the major streams. The LBITP will have little effect on natural riverine overflow, except in the most severe (infrequent) precipitation events. The area in the Lake Houston discharge vicinity is within the 100-year mapped floodplain, but there would be no increase in the floodplain's extent, as overland flow would be conveyed along the canal and would not cross the canal alignment. Wetlands outside the LBITP alignment that depend on hydrology from riverine overflow are also not anticipated to be affected by the LBITP.

In addition to the canal alignment's direct impacts on wetlands resources, the LBITP canal side berms present potential impediments to overland flow, some of which may supply runoff to wetlands located away from the alignment. Most wetlands outside the 100-year floodplain would be expected to be depressional in nature, and would therefore be expected to have direct precipitation as a hydrology source. However, the overland flow scenarios described above would be designed to convey the upgradient runoff volume across the canal alignment and to convey the amount of initial rainfall and runoff through overland flow on the downgradient side of the siphon structures. This would be accomplished by designing the LBITP side ditches to permanently hold water which, in effect, would pre-charge the ditches with runoff volume. This design feature allows overland flow to continue across the canal alignment at the surface expression of the siphon structures. Wetlands adjacent to but not directly impacted by the LBITP ROW and depend on runoff for hydrology would not be significantly impacted by the canal conveyance system.

A more detailed explanation about the design issues and modeling results used to identify siphon locations is provided in Sections 3 and 4 of this DEIS.

The Public Notice for Permit Application No. SWG-2009-00188 provided a review of the Section 404 IP Sketches (Sheets) numbered 1 through 44. The locations for the proposed siphons are provided as shown on Sheets 12-32 (note "siphon" call-outs). Sheet 38 of 44 provides the cross-section and plan view for the siphon structures that eliminate hydrology changes and provide opportunities for safe wildlife crossings.

## 6.3 Water Resources

### 6.3.1 Groundwater

Pumping large water quantities from this aquifer has caused the potentiometric head of the aquifer to decline from between 50 and 350 feet in Region H. By implementing the proposed project, regional groundwater resources would directly and indirectly permanently benefit through conversion to surface water supply sources. Alternative 3A's construction, operation, and maintenance would not be expected to affect groundwater availability in the project area. Therefore, no mitigation is necessary.

#### 6.3.1.1 Water Supply and Conservation

CRPS would be designed to remove primarily sand from the raw water at the intake structure. Several alternatives have been proposed concerning what to do with the sediment removed from the water. These alternatives are as follows.

- Reintroduce the removed sediment back into the river downstream from CRPS.
- Transfer sediment to an onsite dewatering basin; dewater; and store on the CRPS site.
- Reintroduce sediment into the pipeline after the pumps to be conveyed by the pipeline to, and removed in a sedimentation pond at the end of the pipeline.
- Process the sediment slurry through a solid-liquid separator, then haul to an offsite location or store onsite.

The sedimentation basin removes sediment pumped from the Trinity River through the pipelines prior to entering the canal. The sedimentation basin is sized to reduce entry flow velocity so most conveyed sediment will settle to the bottom of the basin and not enter LBITP's canal. The sediment contained within the basin will be removed and stored onsite.

A general layout and impacted footprint for the sedimentation basin has been determined. This footprint includes the area required for the sedimentation basin itself plus approximately 20 acres. The sediment conveyed through the proposed CRPS and pipelines will settle out within the basin and then be mechanically removed from the basin for permanent onsite storage.

Due to the limited nature of LBITP's preliminary phase, the sedimentation basin has not been designed in detail, and the present layout is conceptual. Managing the sediment in the long-term will be consistent with Coastal Water Authority's (Applicant) operations at the Trinity River Pump Station (TRPS). Stock-pile areas are available for LBITP's 60-year life.

As designed, the canal is clay lined to limit infiltration losses and maximize LBITP's cost efficiency and yield. Some infiltration is required to establish new and maintain the existing riparian tree corridor; however, this would increase infiltration losses, reduce LBITP's yield, and increase the water cost per MGD delivered to Lake Houston.

The Trinity River Authority's (TRA) operations staff at Lake Livingston coordinate with the existing Applicant's TRPS to maintain river inflow to meet downstream water demands. Releases from Lake Livingston occur to allow the existing TRPS to remove the amount permitted under existing water rights. A similar operational scheme would be implemented for LBITP to meet demands at the CRPS diversion point. Flows between CRPS and the existing TRPS and flows downstream from the TRPS are currently controlled by the pumping operations at existing TRPS and Lake Livingston releases. Flows downstream from CRPS would be maintained to match or exceed the minimum levels currently experienced in the Trinity River, which is controlled by the demand at the existing TRPS.

Low flows upstream from CRPS would be slightly increased to allow for water withdrawal at the Capers Ridge permitted diversion point and the existing TRPS. Increased flows from Lake Livingston reservoir would occur in the Trinity River during low flow conditions or dry periods. An increase in the reservoir capture rate may be needed to maintain storage for meeting downstream water rights demands after implementing the LBITP. Peak flow truncation or minimization may become slightly more pronounced downstream from the TRPS, although the effect would be minimized through increased downstream tributary contributions to the Trinity River.

Additional flood storage would be available in Lake Livingston due to the projected increase in releases from Lake Livingston to meet the permitted downstream water rights implemented at the permitted Capers Ridge diversion point and the TRPS. This is a net positive effect, as peak flood flows would be slightly attenuated, minimizing flood damage, stream scour and geomorphologic changes downstream from the Lake Livingston reservoir. Slight reductions experienced during Trinity River flood flows would not be expected to negatively impact Trinity River aquatic habitat or resources.

The preliminary Lake Houston outfall design is illustrated by the Section 404 IP Sheet 33. Water level control structures would be designed and constructed along the canal to maintain the canal's water elevation; these structures are depicted on Sheet 37. The Lake Houston outfall or discharge structure will transition the canal at a concrete drop structure and headwall along Lake Houston's bank. Three 8-foot by 6-foot box culverts would convey flow, which would be diverted 36 degrees to the south of the canal centerline near Lake Houston's bank. The diversion angle was modeled and selected to minimize the effects from erosion and scour at the existing outfall location. The box culverts would be constructed within Lake Houston's banks and would discharge below the average water surface elevation at that location. The outfall structure would be underwater. The area immediately adjacent to the outfall would be within a concrete basin or apron beneath the existing channel bottom, and would be surrounded by an underwater concrete weir. This basin and weir structure at the outfall to Lake Houston would prevent lake-bottom scouring and erosion. Shoreline protection would also be required to prevent and limit erosion during low water periods. Based on historical low water elevation information and existing conditions, shoreline protection is recommended to be 60 feet upstream from the outfall location and 120 feet downstream from the outfall location. Based on the outfall erosion investigation's preliminary findings, the outfall is not anticipated to have an adverse effect on the opposite bank or any islands within the existing outfall channel.

During typical LBITP canal flow conditions and canal water elevations, the potential for Lake Houston bed scour is not significantly increased with the projected outfall volumes. However, during a combination of low water levels in Lake Houston and maximum canal discharge rates, sheer stresses within the outfall area could induce localized erosion and scour. The erosion and outfall investigation conducted for the LBITP recommended:

- A permanent shoreline and bathymetric observation program be implemented to monitor the outfall for erosion and scour, and
- Adaptive management procedures to minimize localized environmental effects at the discharge.

CRPS pump operations would be supervised and managed from the existing Lynchburg Pump Station operated by the Applicant. The CRPS pumping rate would be based on Lake Houston water level elevations, water production rates at the Northeast Water Purification Plant (NEWPP) and Lake Houston water demands. The Houston's water rights budget will also have to be monitored and factored into the CRPS pumping rate. The Applicant's operations managers at the Lynchburg facility would advise CRPS operators what their daily pump rate should be. Upon notification, CRPS operators would then operate their pumps at a specified pump rate to meet water demand and operational goals. All CRPS equipment would be controlled, operated and maintained by Applicant's personnel stationed at CRPS.

LBITP's operation would directly impact Lake Houston by importing water from the Trinity River. Increased water demands and associated withdrawals would generally result in lower Lake Houston water level elevations. However, low water levels or changes of approximately 0.5-foot below the normal pool elevation are typically recognized as a problem condition for Lake Houston that should be avoided, according to the Applicant's operations staff. If Lake Houston's water levels recede more than 0.5-foot, complaints are immediately received from Lake Houston area residents. One LBITP operations goal is to maintain Lake Houston's water level at existing conditions. Increased water demand from the Lake Houston intake would result in an increased frequency of lowered lake levels if the water delivery from LBITP is not properly coordinated. Meeting water needs with additional water supply diverted from the Trinity River during critical flow conditions would address the lake level effects to a great extent. However, water may not be diverted from the Trinity River via the LBITP just to maintain Lake Houston's water level. The water rights permit governing CRPS operations does not allow long-term water storage in Lake Houston. Therefore, diversions from the Trinity River must be limited to meet NEWPP's daily water demands.

When Lake Houston is overflowing at the spillway dam due to an inflow rate that exceeds demand, it is anticipated the LBITP would cease operation. Also during emergency conditions such as a hurricane, the LBITP may not be in operation. To examine the worst-case scenario regarding possible future lake level changes, Lake Houston water levels were estimated under two extreme conditions: 1) no inflow from either LBITP or the San Jacinto River, and 2) maximum water demands from Lake Houston in Year 2040. In scenario 2, Lake Houston water levels would drop 0.5-foot from the lake's 44.5 feet MSL level full condition in approximately 3.6 days. Lake Houston water levels would continue to subside to reach a one foot drop after 7.1 days of discontinued LBITP operations combined with maximum water demand from Lake Houston. Under some scenarios, operations associated with diverting water from CRPS may be modified to achieve other goals. As previously stated, a special operational condition would exist when flow is spilled over the Lake Houston dam so the LBITP would not continue to operate. In addition to LBITP's shutdown caused by high flows in the San Jacinto River, high flows in the Trinity River may also result in a need to forego pumping for a time.

### 6.3.2 Surface Water Resources and Quality

Drought conditions in the Trinity River would call for special operational rules. If Trinity River's water level is not adequate to allow for CRPS to operate, additional releases from Lake Livingston may be made to allow adequate water diversion for the LBITP.

In 2000, Houston and the U.S. Geological Survey (USGS) investigated the effects from transferring Trinity River water into Lake Houston, either to augment East Fork of the San Jacinto River (East Fork) stream flow or to replace the West Fork of the San Jacinto River (West Fork) stream flow. The investigation concluded LBITP would not be detrimental to water temperature, ammonia nitrogen, or dissolved oxygen regardless of the water-transfer scenario. Phosphorus and nitrite plus nitrate nitrogen showed fairly large changes if Trinity River water was transferred into Lake Houston to replace West Fork stream flow, and minimal or no change if Trinity River water was transferred to augment East Fork stream flow (USGS 2000). Algal biomass showed large decreases if Trinity River water was transferred into Lake Houston to augment East Fork stream flow, and large increases if Trinity River water was transferred to replace West Fork stream flow. Regardless of the water-transfer scenario modeled, the model results indicate light is the limiting factor for algal biomass growth (Estimated Effects on Water Quality of Lake Houston from Interbasin Transfer of Water from the Trinity River, Texas, USGS Water-Resources Investigations Report 00-4082, 2000).

Espey Consultants, Inc. performed an in-depth evaluation on LBITP's impact on water quality in Lake Houston based on hydrodynamic and water quality modeling (reference: Luce Bayou Interbasin Transfer Project Water Quality Assessment and Hydrodynamic Study 2009). The Water Quality Analysis Simulation Program (WASP) model used helps predict water quality responses to natural conditions. The WASP model is a dynamic compartment-modeling program for aquatic systems that was linked with the Environmental Fluid Dynamics Code (EFDC) hydrodynamic model to help understand LBITP's effects on water quality and the aquatic system given historical flow data, water depths and water mixing.

Based on the EFDC hydrodynamic model used to simulate aquatic systems, Lake Houston's major circulation patterns are primarily influenced by wind and rainfall. Wind effects are dominant for most of the year when flows are at normal levels. Rainfall effects dominate during storm events. Outflows or diversions from Lake Houston consist of overflows from the spillway, release flows from the dam gates and pump withdrawals by the NEWPP, East Water Purification Plant (EWPP) and the San Jacinto River Authority. Overflows from the spillway depend on lake elevation which is, in turn, related to the precipitation amount in the San Jacinto watershed and other inflows and diversions. USGS and the Texas Water Development Board (TWDB) have developed rating curves that relate water surface elevation to flow rates. Release flows from the Lake Houston dam gates depend on reservoir management and maintenance.

The Applicant's operational and water quality goals for Lake Houston include minimizing change to the Lake Houston water level elevations and meeting the daily water demands at the NEWPP by carefully operating the LBITP.

To protect the quality of water being extracted from the Trinity River, the current design includes levees or canal banks which inhibit runoff outside the canal from entering into the canal. This is important, because agricultural runoff often contains pesticides, fertilizers and other contaminants. Engineering a natural stream with no lateral inflows would minimize a natural waterway's benefits.

## 6.4 Environmental Flows

### 6.4.1 Bay and Estuary

LBITP is the TRA to Houston water management strategy anticipated to start in 2020, and represents the permitted diversion of 775 cfs (450,000 acre-feet per year) of water from the Trinity River to the San Jacinto River system (Lake Houston). The TCEQ Certificate of Adjudication 08-4261B allows this diversion at the Capers Ridge site and TRPS by Houston. Freshwater inflow requirements are not established for the authorized water diversion from the Trinity River for the LBITP.

During normal Trinity River flow conditions, sufficient flow is present to meet all downstream water rights. Under low flow conditions, Lake Livingston Dam operators must carefully track raw water withdrawals and release only as much water from the dam as is needed to meet all downstream water rights. Over the past 20 years, flows have generally been maintained above 757 cfs (the 1 percent calculated flow) through releases from the Lake Livingston Dam.

The bay and estuary (B&E) flow pattern to the Galveston Bay system from the Trinity River is due to the combined effects from Region H water management strategies including implementing upstream Region C conservation strategies (reuse and return flows). Region C return flows and Trinity Bay inflows evaluations indicate upstream reuse will have an effect on Galveston Bay inflows. Based on modeling studies, the net effect from the Region H water management strategies after 2010 (including the LBITP diversion) on total B&E flows into Galveston Bay will be minor, although year-to-year variability is anticipated. Cumulative effects encompass secondary and indirect effects. As requested by the USACE, Galveston District (SWG), LBITP's cumulative effects have been developed in accordance with the Texas Department of Transportation's (TxDOT) December 2006 document titled *Guidance on Preparing Indirect and Cumulative Impact Analysis*. This project documentation was compiled as part of the LBITP Environmental Report.

## 6.5 Floodplain Values

The proposed CRPS would be on top of Capers Ridge, which rises above the 100-year floodplain. The majority of the proposed CRPS facilities will be above the 100-year floodplain. CRPS intake structure will be built along Trinity River's western bank. The floodplain's volume loss from constructing the intake structure itself will be compensated by adding floodplain volume through erosion protection (riprap) construction proposed on both sides of the intake structure. This design prevents floodplain volume net loss in the 100-year floodplain.

Additional flood storage will be available in Lake Livingston due to the projected increase in releases to meet the permitted downstream water rights implemented at CRPS and TRPS. This is a net positive effect, as peak flood flows will be slightly decreased, minimizing flood damage, stream scour and geomorphologic changes downstream from the Lake Livingston. Slight reductions in flood flows magnitude do not negatively impact Trinity River aquatic habitat or resources.

## 6.6 Waters of the United States, including Wetlands

A critical goal for LBITP's planning and preliminary design process is to avoid and minimize adverse impacts to the natural environment. Due to LBITP's scale and size (approximately 26.5 miles long and encompassing approximately 1,050 acres), impacts to all environmental resources cannot be avoided. Project alignment planning and detailed alternatives analyses were performed in an effort to minimize impacts to the natural environment including aquatic resources (see Section 2). After identifying the preferred alternative in 2007, the LBITP corridor alignment was further refined to minimize adverse environmental impacts by establishing the project corridor through already disturbed areas, along parcel boundaries, outside the floodplain, and outside forested areas as much as possible. The corridor was aligned, where possible, along upland ridges and through topographic breaks between watersheds. The proposed CRPS footprint was designed to minimize impacts to aquatic resources, and on approximately 39.2 acres of the CRPS property impacts have been completely avoided. The entrance road to CRPS was routed along existing roads to the extent practicable to minimize environmental effects associated with CRPS access.

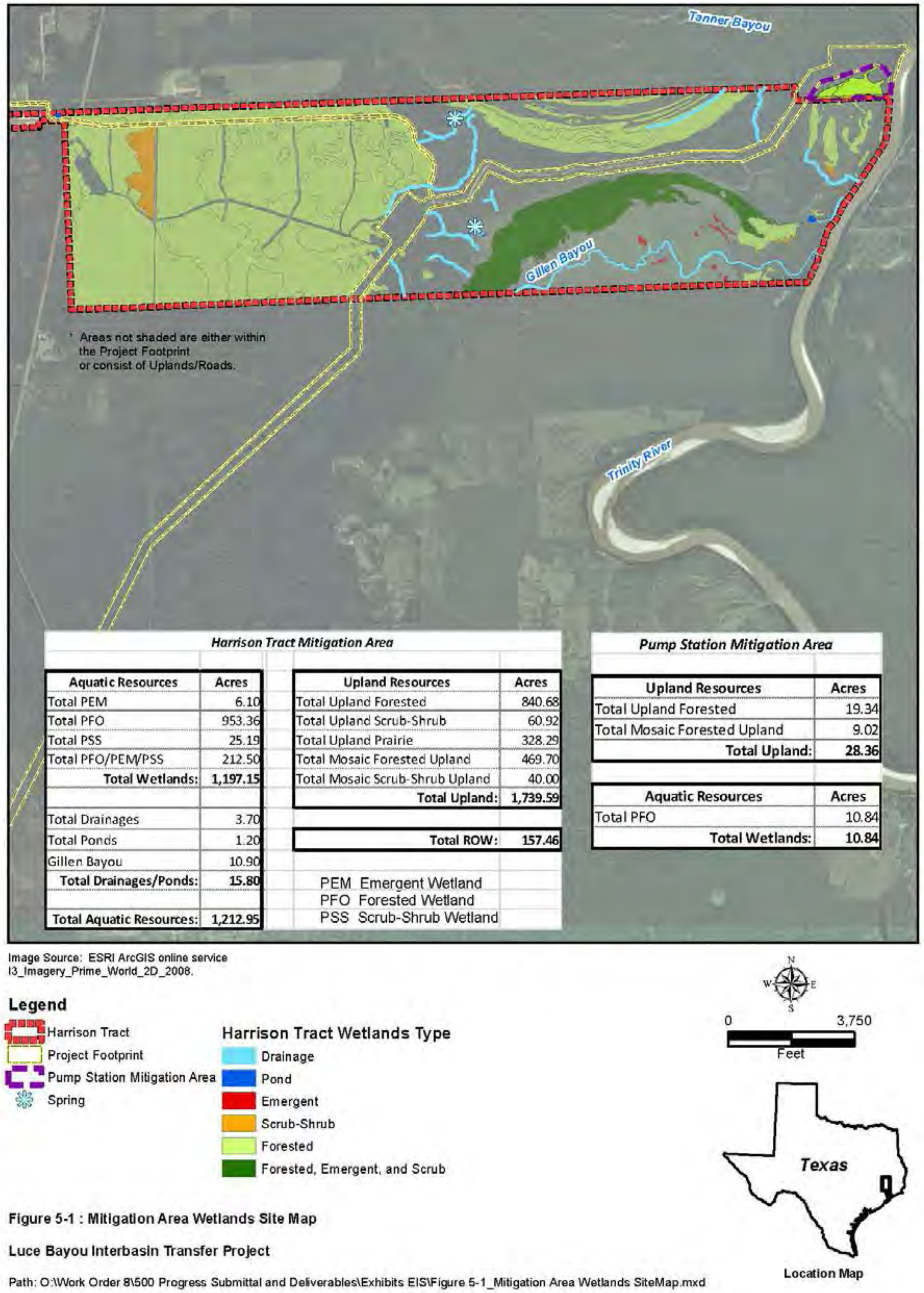
Following negotiations with the local landowner, a high-quality, bottomland, hardwood forested parcel extending to the Trinity River immediately south of the CRPS was acquired for use as part of the mitigation site. LBITP's conceptual compensatory mitigation site could include, as negotiated with the USACE, the surveyed boundary of the Applicant-acquired property for mitigation including the CRPS unencumbered adjoining portion and the bottomland hardwood forested parcel south of CRPS.

The land parcel within the Capers Ridge Focus Area 5 adjacent to the Trinity River in LBITP's far northeastern portion is the proposed site for compensatory mitigation for anticipated impacts to wetlands and other aquatic resources. The acreage offered for mitigation would comply with USACE requirements based on assessing habitat values and functions and potential LBITP impacts determined through field verification. The compensatory mitigation parcel would include portions of the Applicant-acquired property for mitigation (as much as 2,953 acres) and part of the CRPS property (as much as 39 acres). Collectively, these areas proposed for LBITP compensation are known as the LBITP mitigation site. In total, about 1,224 acres of aquatic resources were identified within the mitigation site including roughly 1,208 acres of wetlands and 16 acres of drainages and ponds. The identified wetlands include approximately: 964 acres of forested wetlands, 6 acres of emergent wetlands, 25 acres of scrub-shrub wetlands, and 213 acres of a large wetland area containing forested, emergent, and scrub-shrub components. Uplands within the mitigation site include approximately: 879 forested acres, 328 acres of pastureland, 61 acres of scrub-shrub components, 479 acres of mosaic forested upland, and 40 acres of scrub-shrub mosaic upland (**Table 6-1** and **Exhibit 6-1**).

**Table 6-1:**
**Potential Resources and Type within Mitigation Site**

| Mitigation Areas | Acres |
|---|---|
| **Acquired Mitigation Property** | |
| Aquatic Resource Type | |
| Emergent Wetlands | 6.10 |
| Forested Wetlands | 953.36 |
| Scrub-Shrub Wetlands | 25.19 |
| Forested/Emergent/Scrub-Shrub Wetland | 212.50 |
| Wetlands Subtotal | 1,197.15 |
| Total Drainages | 3.70 |
| Total Ponds | 1.20 |
| Gillen Bayou | 10.90 |
| Drainages/Ponds Subtotals | 15.80 |
| **Total Maximum of Aquatic Resources** | **1,212.95** |
| **Upland Resource Type** | |
| Upland Forested | 840.68 |
| Upland Scrub-Shrub | 60.92 |
| Upland Pastureland | 328.29 |
| Mosaic Forested Upland | 469.70 |
| Mosaic Scrub-Shrub Upland | 40.00 |
| **Total Maximum Upland Resources** | **1,739.59** |
| **CRPS and Acquired Mitigation Property** | |
| Upland Forested | 19.34 |
| Mosaic Forested Upland | 9.02 |
| Total Maximum Upland Resources | 28.36 |
| Aquatic Resources | |
| Forested Wetlands | 10.84 |
| **Total Maximum Wetlands Resources** | **10.84** |
| **Potential Cumulative Maximum of Aquatic Resources** | **1,223.79** |
| **Potential Cumulative Maximum Upland Resources** | **1,767.95** |

**Figure 6-1:**
**Mitigation Area Wetlands Site Map**




*Harrison Tract Mitigation Area*

| Aquatic Resources | Acres |
|---|---|
| Total PEM | 6.10 |
| Total PFO | 953.36 |
| Total PSS | 25.19 |
| Total PFO/PEM/PSS | 212.50 |
| Total Wetlands: | 1,197.15 |
| Total Drainages | 3.70 |
| Total Ponds | 1.20 |
| Gillen Bayou | 10.90 |
| Total Drainages/Ponds: | 15.80 |
| Total Aquatic Resources: | 1,212.95 |

| Upland Resources | Acres |
|---|---|
| Total Upland Forested | 840.68 |
| Total Upland Scrub-Shrub | 60.92 |
| Total Upland Prairie | 328.29 |
| Total Mosaic Forested Upland | 469.70 |
| Total Mosaic Scrub-Shrub Upland | 40.00 |
| Total Upland: | 1,739.59 |
| Total ROW: | 157.46 |

PEM Emergent Wetland
PFO Forested Wetland
PSS Scrub-Shrub Wetland

*Pump Station Mitigation Area*

| Upland Resources | Acres |
|---|---|
| Total Upland Forested | 19.34 |
| Total Mosaic Forested Upland | 9.02 |
| Total Upland: | 28.36 |

| Aquatic Resources | Acres |
|---|---|
| Total PFO | 10.84 |
| Total Wetlands: | 10.84 |

Figure 5-1 : Mitigation Area Wetlands Site Map

Luce Bayou Interbasin Transfer Project

Path: O:\Work Order 8\500 Progress Submittal and Deliverables\Exhibits EIS\Figure 5-1_Mitigation Area Wetlands SiteMap.mxd

**Figure 6-2:
Mitigation Area Wetlands Site Map**

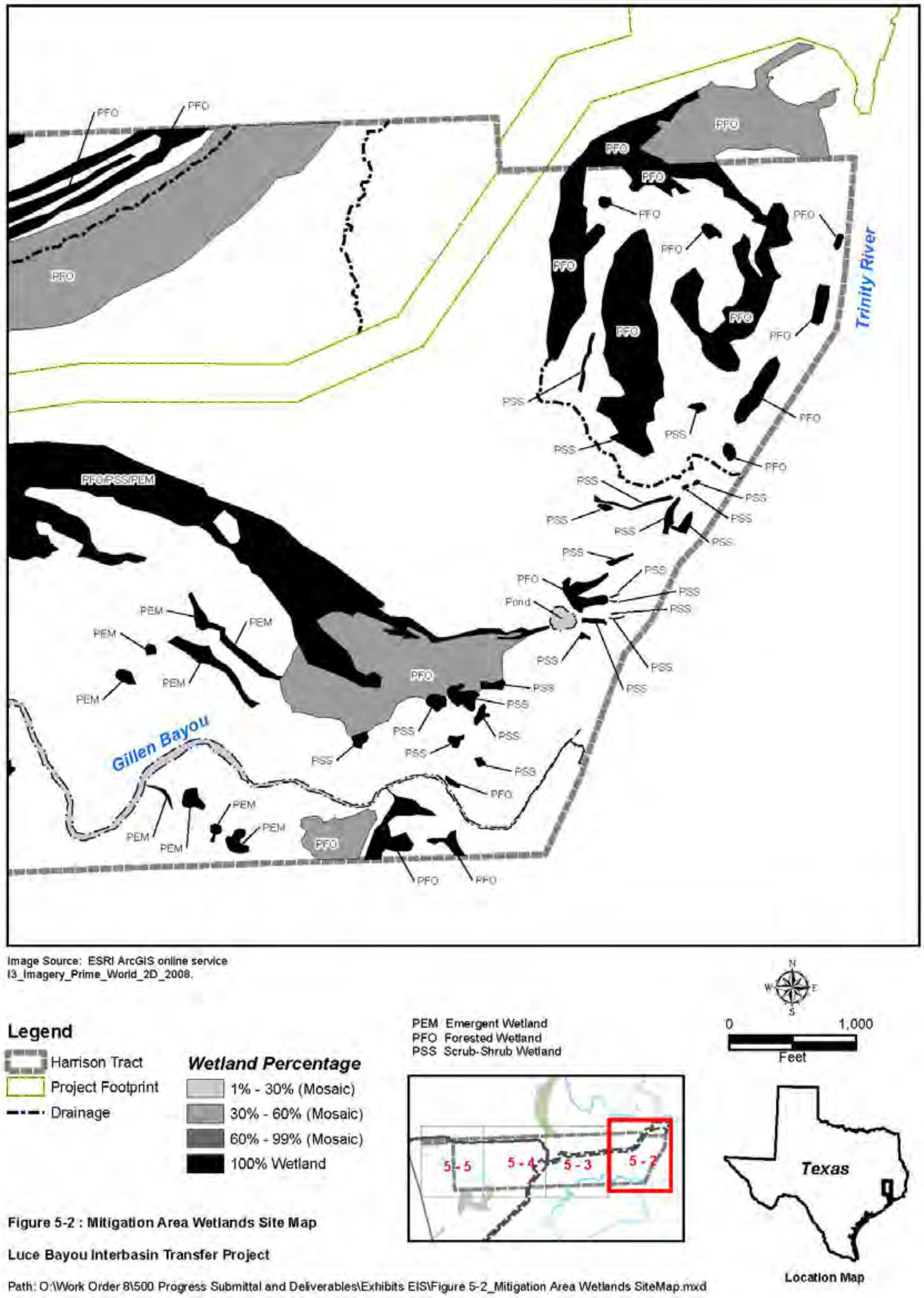


**Figure 6-3:**
**Mitigation Area Wetlands Site Map**

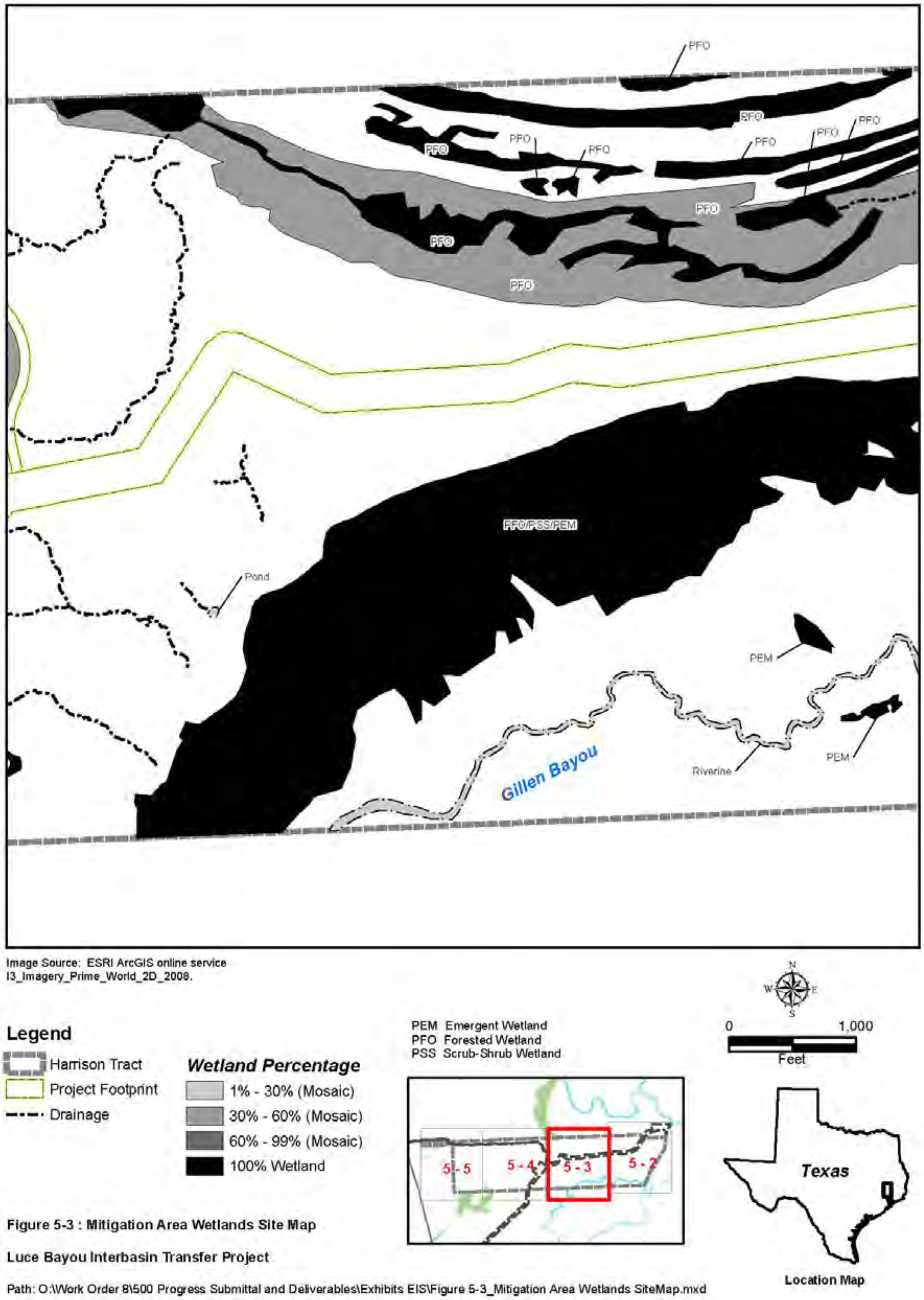


**Figure 6-4:
Mitigation Area Wetlands Site Map**

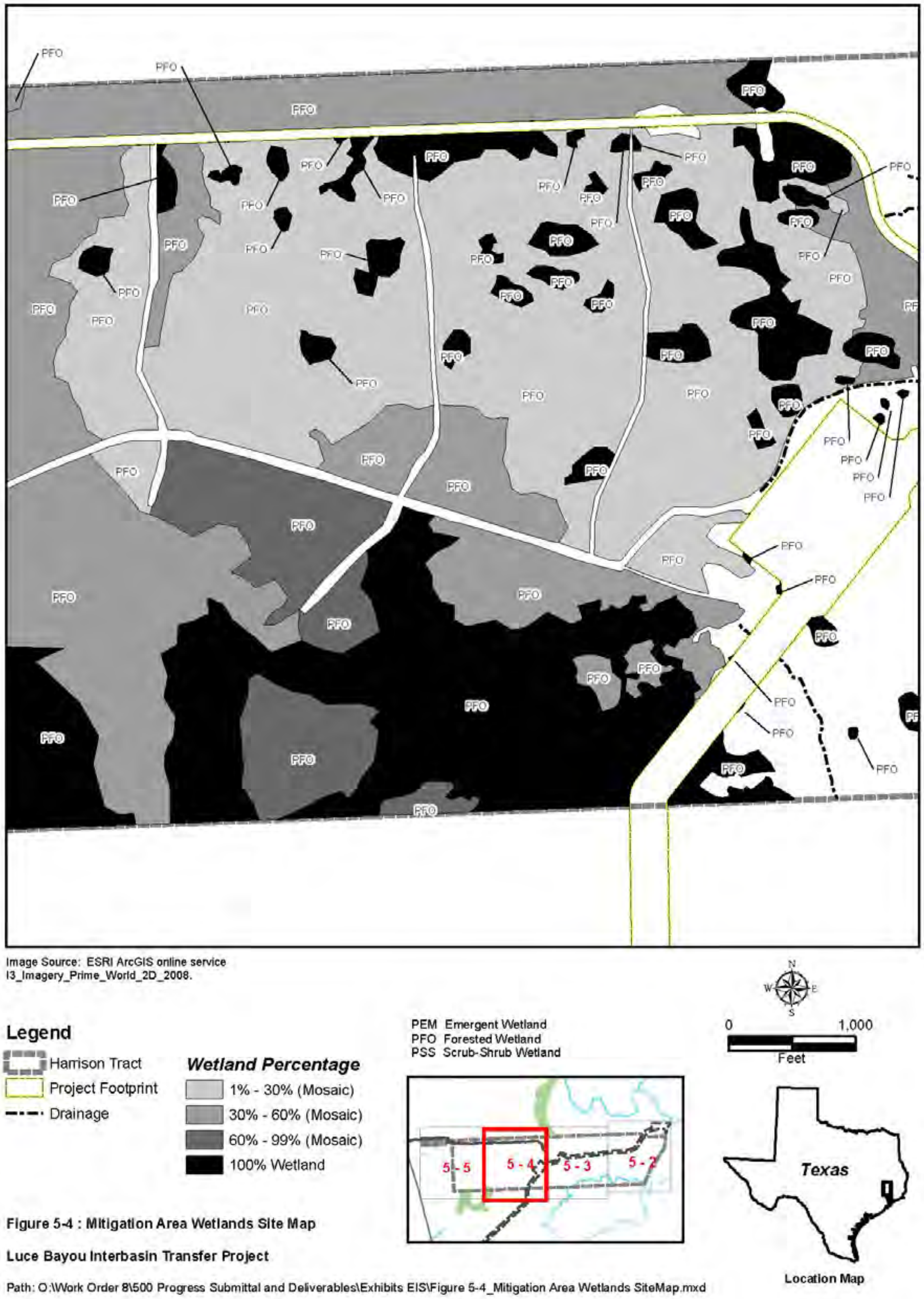
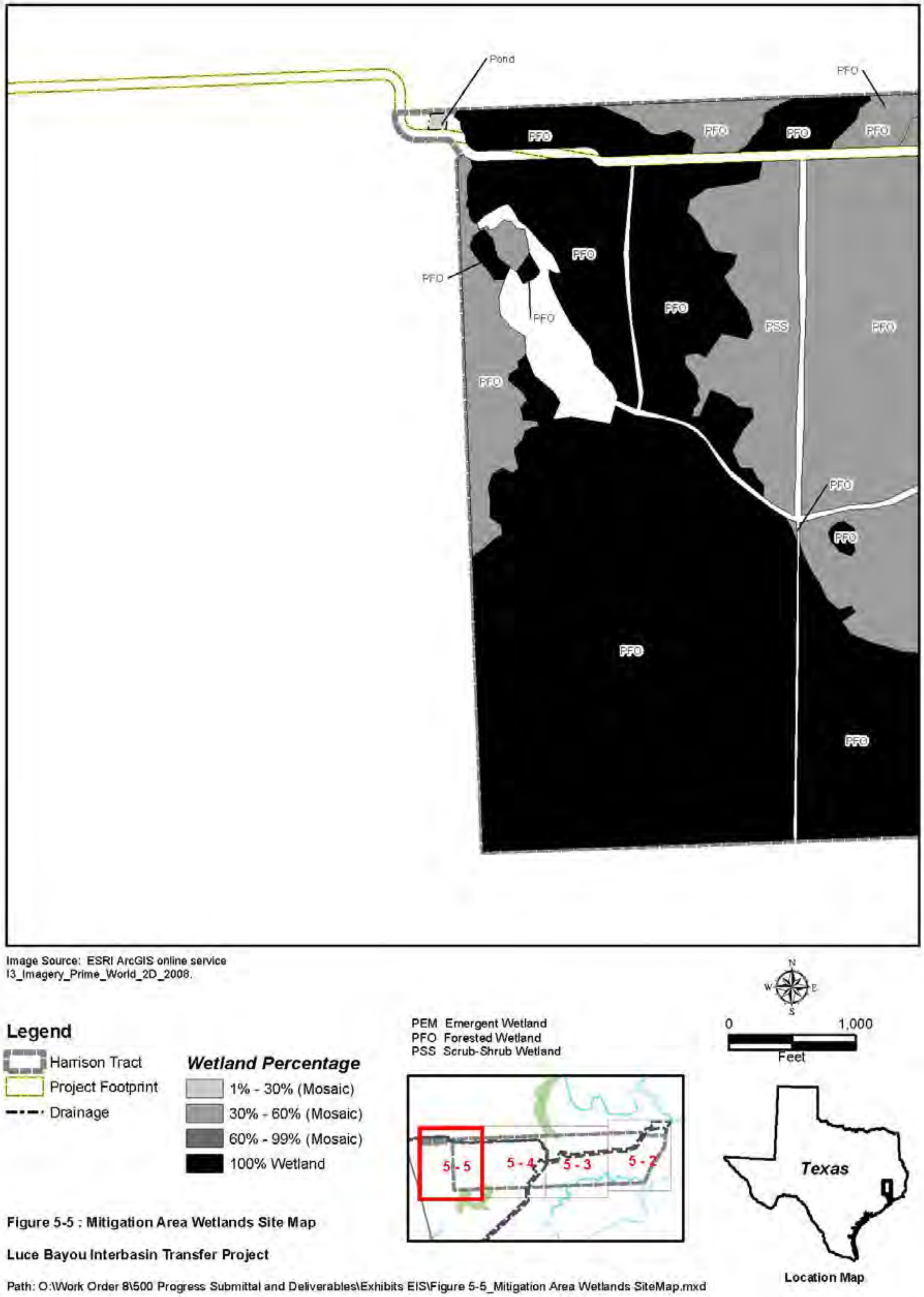


**Figure 6-5:**
**Mitigation Area Wetlands Site Map**



The Applicant acquired the LBITP mitigation site to provide compensation for unavoidable impacts to aquatic resources through preservation. Based on USACE field verification of the wetlands delineations, the necessary mitigation acreage for compensation will be surveyed and deeded to the USFWS to become part of the TRNWR before constructing the LBITP. The majority of the LBITP mitigation site is forested; however, an area has been cleared and is used as pasture. Changes to the landscape have occurred in the past by clearing the Trinity River floodplain (pastureland along Gillen Bayou), drainage improvements, timber harvesting activities, hunting, oil and gas exploration and cattle grazing. Prior to the Applicant's acquisition, candidate areas for compensatory mitigation were threatened with imminent residential land development and clearing of timber resources by the previous property owner.

About 203 acres of jurisdictional aquatic resources have been identified within the portion of the proposed LBITP's footprint, including approximately 201 acres of wetlands. Compensatory mitigation of these impacted wetlands is required under the 2008 Final Rule. The 2008 Final Rule establishes methods that identify the acceptable level of wetland mitigation credits for unavoidable impacts to aquatic resources based on the function and value of the impacted natural resources. LBITP's compensation requirements would depend on the type and quality of the replacement wetlands needed as determined by a functional assessment.

### 6.6.1 Function and Value Modeling

A wetland evaluation based on implementing two different models was conducted for the LBITP mitigation site. These models analyzed and compared the functions and services to preserve the proposed LBITP mitigation site wetlands to those wetlands possibly impacted by LBITP construction. This evaluation helps establish the necessary mitigation property size to be conveyed to the USFWS for preservation to achieve compensation for anticipated wetland impacts associated with the LBITP.

### 6.6.2 Wet 2.0 Method

The WET 2.0 method was used to evaluate the relative value of the wetland areas within the proposed LBITP mitigation site as compared with those that would be impacted by construction within LBITP's alignment. Typical wetlands within the proposed mitigation site and along LBITP's alignment were each evaluated using the WET 2.0 method with the results compared one to another. The regional priority for each function/value assessment was determined using the values established for the Greens Bayou Wetlands Mitigation Bank. While these values may not accurately reflect the regional priorities for the LBITP area or those of the LBITP mitigation site, they provided a baseline from which the relative wetland area values was compared and evaluated.

The Quality Point Scores (QPS) for each wetland area was calculated by dividing the sum of the total scores for Social Significance and Effectiveness derived from the WET 2.0 method by the sum of the maximum possible score for the wetlands, given their regional priorities. Wetland credits were calculated by multiplying the QPS by the impact acreage. About 203 acres of aquatic resources would be impacted by LBITP construction activities. As determined through wetlands impact verification and through the method approved by the USACE, the proposed LBITP mitigation site would contain approximately 1,224 acres of aquatic resources that would be preserved. **Table 6-2** and **Table 6-3** summarize the QPS and calculated wetland credits for the proposed LBITP alignment and the proposed LBITP mitigation site.

**Table 6-2:
Proposed Alignment Wetlands Quality Point Scores (QPS) and Wetland Credits Using WET 2.0 Method**

| Function Value | Actual Score | Max. Score | QPS (Actual Score/ Maximum Score) | Proposed Impacts (Acres) | Wetland Credits (Potential Impact Acreage x QPS) |
|---|---|---|---|---|---|
| Social Significance | 49 | 63 | - | - | - |
| Effectiveness | 42 | 78 | - | - | - |
| TOTAL | 91 | 141 | 0.645 | 203.1 | 130.99 |

**Table 6-3:
Proposed Mitigation Site Aquatic Resources Quality Point Scores (QPS) and Wetland Credits Using WET 2.0 Method**

| Function Value | Actual Score | Max. Score | QPS (Actual Score/ Maximum Score) | Acreage | Wetland Credits (Potential Impact Acreage x QPS) |
|---|---|---|---|---|---|
| Social Significance | 53 | 63 | - | - | - |
| Effectiveness | 42 | 78 | - | - | - |
| TOTAL | 95 | 141 | 0.674 | 1,223.79 | 824.83 |

### 6.6.3 Interim Hydrogeomorphic Model

The LBITP mitigation site includes large forested wetland areas with valuable timber which could be harvested. Some emergent wetlands are in a pasture used to graze cattle and are routinely mowed. Vegetation control is managed by using herbicides. Preserving and removing the threat from timber harvesting and cattle grazing would protect vegetative and natural resources. Removing the cattle would reduce soil disturbance, pollutants and impacts to vegetation. Ceasing mowing and herbicide application would remove the ongoing impact to vegetation and provide opportunities for habitat restoration. The Interim Hydrogeomorphic Model (HGM) for riverine systems was used to demonstrate the value in preserving the LBITP mitigation site.

To assess the function and value for the wetlands present within the proposed LBITP mitigation site, HGM used data collected for each wetland type identified in the project area (herbaceous, scrub/shrub and forested). The model results were averaged together to provide a typical assessment for each wetland type. The functional capacity index (FCI) coefficient calculated for the average results was multiplied by the acreage for each wetland type within the mitigation site to calculate the functional capacity units (FCUs) for each existing wetland habitat onsite. Wetland types and their associated acreages in the proposed LBITP mitigation site used in these modeling efforts are summarized in **Table 6-1**.

After the FCUs were established for the existing wetland habitats, the Interim HGM models for the same wetland areas were used to calculate impacts associated with lack of aquatic habitat preservation which would occur through timber harvesting or forestry activities. The FCUs from this hypothetical scenario were subtracted from the original FCUs to calculate the potential benefit from preserving the proposed LBITP mitigation site. The specific analysis results by wetland type can be found in **Tables 6-4** through **Tables 6-6**:

**Table 6-4:
Herbaceous Wetlands Interim HGM Analysis**

| Item | FCI Existing | FCU Existing | FCI Impacted | FCU Impacted | Benefit (FCU) | Benefit (FCI) |
|---|---|---|---|---|---|---|
| Storage | 0.76 | 65.36 | 0.74 | 63.64 | 1.72 | 0.02 |
| Maintenance | 0.50 | 43.00 | 0.45 | 38.70 | 4.30 | 0.05 |
| Removal | 0.65 | 55.90 | 0.63 | 54.18 | 1.72 | 0.02 |

**Table 6-5:
Scrub/Shrub Wetlands Interim HGM Analysis**

| Item | FCI Existing | FCU Existing | FCI Impacted | FCU Impacted | Benefit (FCU) | Benefit (FCI) |
|---|---|---|---|---|---|---|
| Storage | 0.65 | 52.65 | 0.32 | 25.92 | 26.73 | 0.33 |
| Maintenance | 0.83 | 67.23 | 0.15 | 12.15 | 55.08 | 0.68 |
| Removal | 0.65 | 52.65 | 0.52 | 42.12 | 10.53 | 0.13 |

**Table 6-6:
Forested Wetlands Interim HGM Analysis**

| Item | FCI Existing | FCU Existing | FCI Impacted | FCU Impacted | Benefit (FCU) | Benefit (FCI) |
|---|---|---|---|---|---|---|
| Storage | 0.87 | 900.45 | 0.55 | 569.25 | 331.20 | 0.32 |
| Maintenance | 0.74 | 765.90 | 0.13 | 134.55 | 631.35 | 0.61 |
| Removal | 0.91 | 941.85 | 0.68 | 703.80 | 238.05 | 0.23 |

### 6.6.4 Modeling Summary

The WET 2.0 method results suggest the relative importance of the wetlands on the proposed LBITP mitigation site compared to those within the project alignment. There is a direct correlation between credits and wetland functions and services. Wetlands available for preservation on the proposed LBITP mitigation site were found to contain more than 6.3 times more credits than those wetlands unavoidably impacted along the LBITP alignment. The difference in the QPS between the wetlands within the LBITP alignment (0.64) and those within proposed LBITP mitigation site (0.67) suggest an increased Social Significance and Effectiveness for the proposed LBITP mitigation site wetlands. This demonstrates the proposed LBITP mitigation site wetlands exhibit higher functions and services than those wetlands located along the proposed LBITP alignment.

### 6.6.5 Summary

The results from both wetland assessment models indicate the wetlands within the proposed LBITP mitigation site are likely a higher quality and exhibit a greater Social and Ecological Significance than those in the area that would be impacted by constructing the LBITP.

The 2008 Final Rule establishes a compensatory mitigation requirement hierarchy which includes permittee-responsible mitigation as an option. The proposed permittee-responsible compensatory mitigation plan includes property acquisition by the Applicant, surveying the mitigation property boundaries based on USACE requirements, preserving forested, mosaic and emergent wetlands, upland forests and pasturelands, and ultimately transferring the surveyed property to the TRNWR for long-term protection and management. Based on the 2008 Final Rule, preserving the mitigation property may be used to provide compensatory mitigation since the following criteria have been met.

- Preserved resources provide important physical, chemical or biological functions for the watershed.
- Preserved resources contribute significantly to the ecological sustainability of the watershed.
- Preservation is appropriate and practicable.
- Resources are under threat of destruction or adverse modification.
- Preserved property would be permanently protected through an appropriate real estate or legal instrument such as, in this case, transfer of ownership to the USFWS.

As presently conceptualized, the compensatory mitigation site would be determined based field verification results on the impacted wetlands within the LBITP footprint. The mitigation site would include surveyed areas of the Applicant-acquired property, and could include a portion of the CRPS property supplemented with land acquired from an adjoining property owner. The Applicant has worked to acquire property to satisfy compensatory mitigation requirements for anticipated impacts to aquatic resources associated with implementing the LBITP. The LBITP has avoided and then minimized impacts to the extent possible in accordance with the Rivers and Harbors Act, Section 10 and the Clean Water Act, Section 404 requirements. Long-term LBITP mitigation site preservation is expected to be through transferring title ownership to the USFWS, with the property becoming part of the TRNWR and managed in accordance with the TRNWR Comprehensive Conservation Management Plan.

### 6.6.6 Waters of the United States, including Wetlands

The USACE requires avoidance, minimization and then compensatory mitigation for lost function and value of wetlands affected by a project. The USACE would require a compensatory mitigation plan as part of the Section 404 IP process for the LBITP. Executing the approved mitigation plan would become a condition for issuing the permit. The approved mitigation plan would provide a detailed discussion about mitigation commitments for unavoidable impacts to jurisdictional waters of the U.S., including wetlands. This section provides a more in-depth description about proposed compensatory mitigation for the LBITP.

Considering the effects from the USFWS-recommended LTRFHSP with land acquisition as part of USFWS and partners' actions, a Finding of No Significant Impact (FONSI) was signed by the USFWS' Acting Regional Director, Frank Shoemaker, on March 4, 1999. The FONSI and environmental documentation establishes the LTRFHSP and hence the TRNWR within the designated Focus Area 5.

Capers Ridge is identified as Focus Area 5 in the LTRFHSP, and has been identified as a first priority acquisition area by the USFWS. A National Environmental Policy Act Environmental Assessment document was developed to assess and understand the purpose and need, alternatives, and the environmental impacts associated with establishing the LTRFHSP along the floodplain of the Lower Trinity River from Trinity Bay from Liberty, Polk, and San Jacinto Counties, Texas to Lake Livingston. Refuge land acquisition by the USFWS and various partners for property identified within the LTRFHSP area was identified as the preferred alternative by the impact assessment documentation.

The preferred alternative provided the greatest benefit to habitats and wildlife with a high potential for success. The public/private ownership process provides alternatives and opportunities for cooperation and coordination to achieve long-term stewardship of important Trinity River bottomland habitats and the wildlife. LTRFHSP's goals include conserving migratory birds, protecting scarce and vulnerable wetlands types, and maintaining natural biological diversity. These goals have been met by acquiring and managing floodplain and bottomland forested areas along the Trinity River and preserving them as part of the TRNWR under the LTRFHSP.

Acquiring property within Focus Area 5 was recommended and approved for inclusion in TRNWR by the USFWS in 1999. The conceptual LBITP compensatory mitigation property is part of Focus Area 5, which encompasses approximately 20,000 acres of land within the Trinity River floodplain as described by the USFWS. Focus Area 5 is described as relatively intact bottomland hardwood forest and associated wetlands including nationally recognized important, scarce and vulnerable wetland types and several exceptional and unique community types. Focus Area 5 was deemed critical for conserving migratory birds, protecting scarce and vulnerable wetland types, and maintaining natural biological diversity in the lower Trinity River floodplain. The primary habitats in the area include all bottomland forest types (broad leaf, narrow leaf and needle leaf deciduous), marshes, oxbows and shallow bayous. The unique ridge trending east-west through Focus Area 5 contains a moderate amount of pine and mixed hardwood forest resources which may be seasonally to temporarily flooded, and a moderate amount is classified as important, scarce and vulnerable wetlands. Habitats in this area are particularly important to wintering waterfowl and interior forest birds. As noted by the USFWS environmental assessment, timber harvesting occurred south of Focus Area 5 within the floodplain from 1992 to 1997 as evidenced by aerial photographic documentation. Natural resource values for the proposed area are threatened by timber production, sand and gravel mining, planned residential development, and oil and gas exploration and production. The habitat quality was described as moderate to high for Focus Area 5.

Under the 2008 Final Rule, mitigation requirements could be satisfied in a variety of ways including permittee-responsible mitigation. Other alternatives include preserving wetlands by establishing conservation easements, purchasing wetlands credits at an established mitigation bank, enhancing and/or restoring existing wetlands, and constructing new wetlands. Offsite wetland mitigation alternatives may include restoring uplands surrounding wetland habitat and/or preserving efforts to ensure sufficient hydrology for constructed or acquired wetland habitat.

As of the application date for the Department of the Army permit, no approved wetlands mitigation banks within the LBITP service area boundaries were available for credit purchase. Thus, the wetlands mitigation bank alternative was eliminated from further consideration. Other alternatives for wetlands mitigation identified by 2008 Final Rule include in-lieu-fee arrangements, wetland creation, or enhancing property currently owned and/or managed by resource agencies within the jurisdiction in the LBITP area. Coordination with the USACE and resource agencies resulted in eliminating onsite mitigation that would require creating or enhancing wetlands as a compensatory mitigation alternative for the LBITP.

Conceptually, the preferred alternative for compensatory mitigation associated with the LBITP incorporates elements of permittee-responsible offsite mitigation with wetlands and habitat preservation through property deed acquisition and transferring ownership to the USFWS for long-term protection, management and monitoring. The conceptual mitigation alternative is to acquire a portion of LTRFHSP's Focus Area 5, and transfer the property by unencumbered deed to the USFWS for preservation and inclusion within the TRNWR in perpetuity. The Focus Area 5 property, and an unencumbered part of the CRPS property, would provide compensation for unavoidable environmental impacts to waters of the U.S., including wetlands associated with implementing the LBITP. The USFWS would preserve and manage the property in accordance with the TRNWR Comprehensive Conservation Management Plan.

Resulting from the conceptual compensatory mitigation plan for the LBITP developed during consultation with regulatory and resource agencies, the Applicant acquired an approximate 3,000-acre property at an offsite area. The Applicant will preserve and protect this property against threats from development and other impact including logging activities. The proposed mitigation property is in proximity to Luce Bayou, San Jacinto River, and Trinity River watersheds and within comparable Hydrologic Unit Code zones. Discussions have included property conveyance by deed or conservation easement. The proposed mitigation property contains the geomorphic feature known as Capers Ridge. The proposed mitigation property is within the Lower Trinity River Floodplain Habitat Stewardship Program (LTRFHSP) acquisition boundary established in 1999 by the USFWS for the Trinity River National Wildlife Refuge (TRNWR). The USFWS promotes active stewardship for important remnant habitats approximately 105,000 acres in size within eight designated focus areas in the lower Trinity River floodplain. These focus areas are part of the USFWS NWR system and are included as the TRNWR.

In late September and early October 2009, approximately 200 acres of hardwoods were selectively harvested on the mitigation property, primarily in the southwestern area. Impacts to the mitigation property included minor surface disturbances, woody debris piles from logging machinery, and changes in tree canopy cover for these logged areas. Vegetative response in these impacted areas has been monitored since the logging has occurred. Complete revegetation has occurred in areas impacted by the selective logging, most notably within the herbaceous layer. The vegetation emergence from existing seed banks has been exceptional and has resulted in a lower invasive species (Chinese tallow, Triadica sebifera) emergence than previously expected, especially in wetter areas. The amount of wetland acreage loss appears to be minimal. The lost forested wetlands are being naturally restored and are revegetating as emergent wetlands. With the impacts to the forested wetlands and the conversion loss from forested to emergent wetlands, sufficient mitigation for the proposed LBITP exists by transferring the mitigation property to the USFWS.

Once the USFWS receives the mitigation property, it will become part of the TRNWR and be managed in accordance with the Comprehensive Conservation Management Plan.

### 6.6.7 Wetland and Waterbody Construction and Mitigation Procedures

A SWPPP prepared for compliance with the EPA's National Storm Water Program General Permit requirements will be available for each contractor in the field. The SWPPP shall contain Spill Prevention and Response Procedures which meet state and federal agency requirements. Spill Prevention and Response Procedures are also contained in the Applicant's SPCC Plan.

### 6.6.8 Agency Coordination

The Applicant would coordinate with the appropriate local, state and federal agencies regarding mitigation.

## 6.7 Waterbody Crossings

### 6.7.1 Notification Procedures and Permits

The Applicant would apply to the USACE or its delegated agency for the appropriate wetland and water body crossing permits.

The Applicant would provide written notification to authorities responsible for potable surface water supply intakes located within three miles downstream from the crossing at least one week before beginning work in the waterbody or as otherwise specified by that authority.

The Applicant would apply for state-issued waterbody crossing permits, and obtain individual or generic Section 401 water quality certification or waiver.

The Applicant would notify appropriate state authorities at least 48 hours before beginning trenching or blasting within the waterbody or as specified in state permits.

### 6.7.2 Time Window for Construction

Unless expressly permitted or further restricted by the appropriate state agency in writing on a site-specific basis, instream work required to install or remove equipment bridges must occur during the following time windows:

- Coldwater fisheries – June 1 through September 30
- Coolwater and warmwater fisheries – June 1 through November 30
- Trinity River – February 15 through March 15

The Texas Department of Parks and Wildlife’s in-water work window for the portion of the Trinity River crossed by the project is between February 15 and March 15.

### 6.7.3 Extra Work Areas

Locate all extra work areas (such as staging areas and additional spoil storage areas) which are at least 50 feet away from the water’s edge, except where the adjacent upland consists of actively cultivated or rotated cropland or other disturbed land.

The project sponsor shall file a site-specific construction plan for each extra work area with less than a 50-foot setback from the water’s edge (except where the adjacent upland consists of actively cultivated or rotated cropland or other disturbed land) and a site-specific explanation about the conditions that will not permit a 50-foot setback. This should be filed with the Secretary for review in addition to a written approval by the Director.

Extra work areas should limit the clearing of vegetation between extra work areas and the edge of the waterbody to the certificated construction ROW. The size of the extra work areas should also be limited to the minimum amount necessary to construct the waterbody crossing.

### 6.7.4 General Crossing Procedures

Comply with USACE or its delegated agency’s permit terms and conditions. Construct crossings as close to perpendicular to the axis of the waterbody channel as engineering and routing conditions permit.

If the pipeline runs parallel to a waterbody, attempt to maintain at least 15 feet of undisturbed vegetation between the waterbody (and any adjacent wetland) and the construction ROW. In areas where waterbodies meander or have multiple channels, route the pipeline to minimize the number of waterbody crossings.

Adequate flow rates should be maintained to protect aquatic life and to prevent the interruption of existing downstream uses. Waterbody buffers (extra work area setbacks, refueling restrictions, etc.) must be clearly marked in the field with signs and/or highly visible flagging until construction-related ground disturbing activities have been completed.

### 6.7.5 Spoil Pile Placement and Control

All spoil from minor and intermediate waterbody crossings and upland spoil from major waterbody crossings must be placed in the construction ROW at least 10 feet from the water’s edge or in extra work areas. Sediment barriers should be used to prevent spoil or heavily silt-laden water from flowing into any waterbody.

### 6.7.6 Equipment Bridges

Only clearing equipment and equipment necessary for installing equipment bridges may cross waterbodies prior to bridge installation, and the crossings should be limited to one per piece of clearing equipment.

Equipment bridges should be used to maintain unrestricted flow and to prevent soil from entering the waterbody. Examples of such bridges include:

- Equipment pads and culvert(s),
- Equipment pads or railroad car bridges without culverts,
- Clean rock fill and culvert(s) and
- Flexi-float or portable bridges.

Additional options for equipment bridges may be used to achieve the performance objectives noted above. Soil should not be used to construct or stabilize equipment bridges.

Design and maintain each equipment bridge to withstand and pass the highest flow expected to occur while the bridge is in place. Align culverts to prevent bank erosion or streambed scour. If necessary, install energy dissipating devices downstream from the culverts.

Design and maintain equipment bridges to prevent soil from entering the waterbody.

Remove equipment bridges as soon as possible after permanent seeding, unless USACE or its delegated agency authorizes it as a permanent bridge.

If there will be more than one month between final cleanup and beginning permanent seeding and reasonable alternative ROW access is available, remove equipment bridges as soon as possible after final cleanup.

### 6.7.7 Dry-Ditch Crossing Methods

Unless approved otherwise by the appropriate state agency, install the pipeline using one of the dry-ditch methods outlined below for crossings waterbodies up to 30 feet wide (measured at the water's edge at the time of construction).

### 6.7.8 Dam and Pump

The dam-and-pump method may be used without prior approval for crossing waterbodies where pumps can adequately transfer stream flow volumes around the work area and there are no concerns about sensitive species passage. Implementing the dam-and-pump crossing method must meet the following performance criteria'

- Use sufficient pumps, including onsite backup pumps, to maintain downstream flows.
- Construct dams with materials that prevent sediment and other pollutants from entering the waterbody (e.g., sandbags or clean gravel with plastic liner).
- Screen pump intakes.
- Prevent streambed scour at pump discharge.
- Monitor the dam and pumps to ensure proper operation throughout the waterbody crossing.

### 6.7.9 Crossings Minor Waterbodies

Where a dry-ditch crossing is not required, minor waterbodies may be crossed using the open-cut crossing method with the following restrictions.

- Except for blasting and other rock breaking measures, complete instream construction activities (including trenching, pipe installation, backfill, and restoring the streambed contours) within 24 hours. Streambanks and unconsolidated streambeds may require additional restoration after this period.
- Limit use of equipment operating in the waterbody to those needed to construct the crossing.
- Equipment bridges are not required at minor waterbodies which do not have a state-designated fishery classification (e.g., agricultural or intermittent drainage ditches). However, if an equipment bridge is used, it must be constructed.

### 6.7.10 Crossings Intermediate Waterbodies

Where a dry-ditch crossing is not required, intermediate waterbodies may be crossed using the open-cut crossing method with the following restrictions.

- Complete instream construction activities (not including blasting and other rock breaking measures) within 48 hours, unless site-specific conditions make completion within 48 hours unfeasible.
- Limit use of equipment operating in the waterbody to those needed to construct the crossing.
- All other construction equipment must cross on an equipment bridge.

### 6.7.11 Crossings Major Waterbodies

Before construction, the project sponsor shall file a detailed, site-specific construction plan and scaled drawings identifying all areas to be disturbed by construction for each major waterbody crossing. The scaled drawings are not required for any offshore portions of pipeline projects. This filing should be done with the Secretary for the review along with a written approval by the Director. This filing should be developed in consultation with the appropriate state and federal agencies, and should include extra work areas, spoil storage areas, sediment control structures, etc., plus mitigation for navigational issues.

The Environmental Inspector (EI) may adjust the final placement for the erosion and sediment control structures in the field to maximize effectiveness.

### 6.7.12 Temporary Erosion and Sediment Control

Install sediment barriers (as defined in the Applicant's Plan, Section 4.0) immediately after initially disturbing the waterbody or adjacent upland. Sediment barriers must be properly maintained throughout construction and reinstalled as necessary (such as after backfilling the trench) until replaced by permanent erosion controls or the adjacent upland areas restoration is complete. Temporary erosion and sediment control measures are addressed in more detail in the Applicant's Plan; however, the following specific measures must be implemented at stream crossings.

- Install sediment barriers across the entire construction ROW at all waterbody crossings, where necessary, to prevent sediments from flowing into the waterbody. In the travel lane, these may include removable sediment barriers or drivable berms. Removable sediment barriers can be removed during the construction day, but must be reinstalled after construction has stopped for the day and/or when heavy precipitation is imminent.
- Where waterbodies are adjacent to the construction ROW, install sediment barriers along the edge of the construction ROW as necessary to contain spoil and sediment within the construction ROW.

- Use trench plugs at all waterbody crossings, as necessary, to prevent water from diverting into upland portions of the pipeline trench and to keep any accumulated trench water out of the waterbody.
- The existing TRPS currently has a sediment basin located on-site.

### 6.7.13 Trench Dewatering

Dewater the trench (either on or off the construction ROW) in a manner which does not cause erosion and does not result in heavily silt laden water flowing into any waterbody. Remove the dewatering structures as soon as possible after completing dewatering activities.

### 6.7.14 Restoration

Use clean gravel or native cobbles for the upper 1-foot of trench backfill in all waterbodies containing coldwater fisheries.

For open-cut crossings, stabilize waterbody banks and install temporary sediment barriers within 24 hours of completing instream construction activities. For dry-ditch crossings, complete streambed and bank stabilization before returning flow to the waterbody channel.

Return all waterbody banks to preconstruction contours or to a stable angle of repose as approved by the EI.

Riprap applications for bank stabilization must comply with USACE or its delegated agency's permit terms and conditions. Unless otherwise specified by state permit, limit using riprap to areas where flow conditions preclude effective vegetative stabilization techniques such as seeding and erosion control fabric.

Revegetate disturbed riparian areas with conservation grasses and legumes or native plant species, preferably woody species. Specific native species will be identified in the Applicant's Revegetation and Restoration Plan.

Install a permanent slope breaker across the construction ROW at the base of slopes greater than 5 percent and less than 50 feet from the waterbody, or as needed to prevent sediment transport into the waterbody. Also install sediment barriers as outlined in the Applicant's Revegetation and Restoration Plan. With the EI's approval, in some areas an earthen berm may be suitable as a sediment barrier adjacent to the waterbody.

These measures also apply to those perennial or intermittent streams not flowing at the time of construction.

### 6.7.15 Post-Construction Maintenance

Limit vegetation maintenance adjacent to waterbodies to allow a riparian strip of at least 25 feet wide, as measured from the waterbody's mean high water mark, to permanently revegetate with native plant species across the entire construction ROW. However, to facilitate periodic pipeline corrosion/leak surveys, a corridor centered on the pipeline and up to 10 feet wide may be maintained in an herbaceous state. In addition, trees greater than 15 feet tall within 15 feet of the pipeline may be cut and removed from the permanent ROW.

In forested areas, the Applicant proposes to only remove trees within a permanently maintained project corridor.

Herbicides or pesticides should not be used in or within 100 feet of a waterbody, except as allowed by the appropriate land management or state agency.

### 6.7.16 Wetland Crossings

The project sponsor shall conduct a wetland delineation using the current federal method and file a wetland delineation report with the Secretary before construction. This report shall identify:

- By milepost all wetlands that would be affected,
- The National Wetlands Inventory (NWI) classification for each wetland,
- The crossing length for each wetland in feet, and
- The area of permanent and temporary disturbance that would occur in each wetland by NWI classification type.

The requirements outlined in this section do not apply to wetlands in actively cultivated or rotated cropland. Standard upland protective measures including workspace and topsoiling requirements apply to these agricultural wetlands.

Route the pipeline to avoid wetland areas to the maximum extent possible. If a wetland cannot be avoided or crossed by following an existing ROW, route the new pipeline to minimize disturbing wetlands. Where looping an existing pipeline, overlap the existing pipeline ROW with the new construction ROW. Also locate the loop line no more than 25 feet away from the existing pipeline unless site-specific constraints would adversely affect the existing pipeline's stability.

Limit the construction ROW's width to 75 feet or less. Prior written approval from the Director is required where topographic conditions or soil limitations require the construction ROW width within the boundaries of a federally delineated wetland be expanded beyond 75 feet. Early in the planning process, the CWA is encouraged to identify site-specific areas where existing soils lack adequate unconfined compressive strength which would result in excessively wide ditches and/or difficult to contain spoil piles.

Wetland boundaries and buffers must be clearly marked in the field with signs and/or highly visible flagging until construction-related ground disturbing activities have been completed.

Implement the measures in Sections 6.6.7 and 6.6.9, if a waterbody crossing is located within or adjacent to a wetland crossing. If all measures in Sections 6.6.7 and 6.6.9 cannot be met, the CWA must file with the Secretary a site-specific crossing plan for review and written approval by the Director before construction. This crossing plan shall address at a minimum:

- Spoil control,
- Equipment bridges,
- Restoring waterbody banks and wetland hydrology,
- Timing for waterbody crossing,
- Crossing method, and
- Size and location for all extra work areas.

Do not locate aboveground facilities in any wetlands except where the facility's location outside wetlands would prohibit compliance with U.S. Department of Transportation (USDOT) regulations.

### 6.7.17 Installation

#### 6.7.17.1 Extra Work Areas and Access Roads

Locate all extra work areas (such as staging areas and additional spoil storage areas) at least 50 feet away from wetland boundaries, except where the adjacent upland includes actively cultivated or rotated cropland or other disturbed land.

The CWA shall file with the Secretary for review and written approval by the Director, a site-specific construction plan for each extra work area with a less than 50-foot setback from wetland boundaries (except where adjacent upland includes actively cultivated or rotated cropland or other disturbed land) and a site-specific explanation about the conditions that will not permit a 50-foot setback.

Limit vegetation clearing between extra work areas and the wetland's edge to the certificated construction ROW.

The construction ROW may be used for access when the wetland soil is firm enough to avoid rutting or the construction ROW has been appropriately stabilized to avoid rutting (e.g., with timber riprap, prefabricated equipment mats, or terra mats).

In wetlands that cannot be appropriately stabilized, all construction equipment other than that needed to install the wetland crossing shall use access roads located in upland areas. Where access roads in upland areas do not provide reasonable access, limit all other construction equipment to one pass through the wetland using the construction ROW.

The only access roads, other than the construction ROW, which can be used in wetlands without Director approval, are those existing roads which can be used with no modification and no impact on the wetlands.

### 6.7.18 Crossing Procedures

Comply with USACE or its delegated agency's permit terms and conditions. Assemble the pipeline in an upland area, unless the wetland is dry enough to adequately support skids and pipe.

Use push-pull or float techniques to place the pipe in the trench where water and other site conditions allow.

Minimize the length of time topsoil is segregated and the trench is open.

When operating in wetland areas, limit construction equipment as necessary to those needed to clear the construction ROW, dig the trench, fabricate and install the pipeline, backfill the trench, and restore the construction ROW.

Cut vegetation just above ground level leaving existing root systems in place, and remove it from the wetland for disposal. Limit pulling tree stumps and grading activities to directly over the trench line. Do not grade or remove stumps or root systems from the rest of the construction ROW in wetlands, unless the Chief Inspector and EI determine safety-related construction constraints require grading or removing tree stumps from under the working side of the construction ROW.

Segregate the top 1-foot of topsoil from the area disturbed by trenching, except in areas where standing water is present or soils are saturated or frozen. Immediately after backfilling has been completed, restore the segregated topsoil to its original location.

Do not use rock, soil imported from outside the wetlands, tree stumps or brush riprap to support equipment on the construction ROW.

If standing water or saturated soils are present, or if construction equipment causes ruts or mixes the topsoil and subsoil in wetlands, use low-ground-weight construction equipment or operate normal equipment on timber riprap, prefabricated equipment mats or terra mats.

Do not cut trees outside the approved construction work area to obtain timber for riprap or equipment mats.

Attempt to use no more than two layers of timber riprap to support equipment on the construction ROW.

Remove all project-related material used to support equipment on the construction ROW after completing construction.

### 6.7.19 Temporary Sediment Control

Install sediment barriers (as defined in the Applicant's Plan, Section 4.0) immediately after initially disturbing the wetland or adjacent upland. Sediment barriers must be properly maintained throughout construction and reinstalled as necessary (such as after backfilling the trench). Except as noted below, maintain sediment barriers until replaced by permanent erosion controls or adjacent upland areas have been completely restored. Temporary erosion and sediment control measures are addressed in more detail in the Applicant's Plan.

Install sediment barriers across the entire construction ROW immediately at upslope of the wetland boundary, including all wetland crossings where necessary to prevent sediment flow into the wetlands.

Where wetlands are adjacent to the construction ROW and the ROW slopes toward the wetlands, install sediment barriers along the construction ROW's edge as necessary to prevent sediment from flowing into the wetlands.

Install sediment barriers along the construction ROW edge as necessary to contain spoil and sediment within the construction ROW through wetlands. Remove these sediment barriers during ROW cleanup.

The natural dynamic processes in a river can result in riverbank and riverbed erosion, which causes the river to meander and form bends in the river, oxbow lakes, small islands and other processes. CRPS is on the outside of a meander bend in the river. The spiral flow at the bend can result in scouring the bank's toe. With the intake structure at this bend, the structure's base in the river will need to be protected to prevent undercutting the structure. The intake structure will tend to deflect flow patterns to the inside of the bend opposite the structure. Using riprap is planned for erosion protection.

### 6.7.20 Trench Dewatering

Dewater the trench (either on or off the construction ROW) in a manner that does not cause erosion and does not result in heavily silt laden water flowing into any wetlands. Remove the dewatering structures as soon as possible after the completing dewatering activities.

### 6.7.21 Restoration

Where the pipeline trench may drain a wetland, construct trench breakers and/or seal the trench bottom as necessary to maintain the original wetland hydrology.

For each wetland crossed, install a trench breaker at the slope base near the boundary between the wetland and adjacent upland areas. Install a permanent slope breaker across the construction ROW at the base of slopes greater than 5 percent where the slope base is less than 50 feet from the wetland, or as needed, to prevent sediment from being transported into the wetland. Also install sediment barriers as outlined in the Applicant's Plan. With the EI's approval, In some areas an earthen berm may be suitable as a sediment barrier adjacent to the wetland.

Fertilizer, lime, or mulch should not be used unless required in writing by the appropriate land management or state agency.

Consult with the appropriate land management or state agency to develop a project-specific wetland restoration plan. The restoration plan should include measures for re-establishing herbaceous and/or woody species, controlling the invasion and spread of undesirable exotic species (e.g., purple loosestrife and phragmites), and monitoring the success of the revegetation and weed control efforts. Provide this plan to the FERC staff upon request.

Until a project-specific wetland restoration plan is developed and/or implemented, temporarily revegetate the construction ROW with annual ryegrass at a rate of 40 pounds/acre (unless standing water is present).

Ensure all disturbed areas successfully revegetate with wetland herbaceous and/or woody plant species.

Remove temporary sediment barriers at the boundary between wetland and adjacent upland areas after upland revegetation and stabilization of adjacent upland areas are judged to be successful as specified in the Applicant's Plan.

### 6.7.22 Post-Construction Maintenance

The Applicant would not conduct vegetation maintenance over the full width of the permanent ROW in wetlands. However, to facilitate periodic pipeline corrosion/leak surveys, a corridor centered on the pipeline and up to 10 feet wide may be maintained in an herbaceous state. Also trees greater than 15 feet tall within 15 feet of the pipeline may be selectively cut and removed from the permanent ROW.

In forested wetlands, the Applicant proposes to only remove trees within a permanently maintained corridor.

Herbicides or pesticides should not be used in or within 150 feet of the wetlands, except as allowed by the appropriate land management agency or state agency.

Annually monitor and record the success of wetland revegetation for the first 3 years after construction, or until wetland revegetation is successful. At the end of 3 years after construction, file a report with the Secretary, identifying the status of the wetland revegetation efforts. Include the percent cover achieved and problem areas (weed invasion issues, poor revegetation, etc.). Continue to file a report annually until wetland revegetation has been successful.

Wetland revegetation shall be considered successful if the cover of herbaceous and/or woody species has at least 80 percent the type, density and distribution of the vegetation in adjacent wetland areas not disturbed by construction. If revegetation is not successful at the end of 3 years, develop and implement (in consultation with a professional wetland ecologist) a remedial revegetation plan to actively revegetate the wetlands. Continue revegetation efforts until wetland revegetation has been successful.

### 6.7.23 Hydrostatic Testing

#### 6.7.23.1 Notification Procedures and Permits

Apply for state-issued water withdrawal permits, as required.

Apply for National Pollutant Discharge Elimination System (NPDES) or state-issued discharge permits, as required.

Notify appropriate state agencies about intent to use specific sources at least 48 hours before testing activities unless they waive this requirement in writing.

### 6.7.24 Operating Guidelines

Perform 100 percent radiographic inspection for all pipeline section welds or hydrotest the pipeline sections before installing under waterbodies or wetlands.

If pumps used for hydrostatic testing are within 100 feet of any waterbody or wetlands, address the pumps' operation and refueling in the project's Spill Prevention and Response Procedures.

The CWA will file a list with the Secretary identifying the location for all waterbodies proposed for use as a hydrostatic test water source or discharge location.

### 6.7.25 Intake Source and Rate

The TRPS site is existing and already has established intake rates that are acceptable. The CRPS site is currently undeveloped with no structures. CRPS will primarily include the pump bays to house the pumps, and the intake structure to allow water from the river to enter the pump bays and be pumped via underground pipeline to a canal that will convey the raw water to Luce Bayou. There will also be a support building and associated equipment to support CRPS.

The intake structure's size is based on reducing the velocity for the water being drawn from the river to be pumped to Lake Houston. The reduced water velocity in the intake allows the pumps to operate at their most efficient level and gives the sands in the suspended sediment time to settle, which reduces the damaging effect the sands would have on the pumps.

The concrete intake structure will be along the river's western bank. Trash racks at the intake structure's entrance protect the pumps from floating debris such as trees, branches, etc., which are carried along in the river and could damage the pumps. The trash racks also hinder aquatic organisms such as fish, turtles, etc. from entering the pump bays. The intake and trash racks are designed so the water velocity approaching the trash rack is low enough aquatic animals are not impinged or entrained on the bars. The rest of CRPS structures are out of the river's floodplain.

Screening and installing an intake hose would prevent fish entrainment.

Do not use state-designated exceptional value waters, waterbodies which provide habitat for federally listed threatened or endangered species, or waterbodies designated as public water supplies unless appropriate federal, state, and/or local permitting agencies grant written permission.

Maintain adequate flow rates to protect aquatic life, provide for all waterbody uses, and provide for downstream withdrawals of water by existing users.

Locate hydrostatic test manifolds outside wetlands and riparian areas to the maximum extent practicable.

### 6.7.26 Discharge Location, Method and Rate

Regulate the discharge rate, use energy dissipation device(s), and install sediment barriers as necessary to prevent erosion, streambed scour, sediment suspension, or excessive streamflows.

Do not discharge into state-designated protected waters, waterbodies which provide habitat for federally listed threatened or endangered species, or waterbodies designated as public water supplies unless appropriate federal, state, and local permitting agencies grant written permission.

## 6.8 Non-Native Wildlife

Invasive species management could supplement the design criteria previously identified. The Applicant would develop measures to control invasive aquatic species within the Trinity River. These measures would be incorporated into the CRPS design and construction, as necessary, to avoid transferring invasive aquatic species from the Trinity River to the San Jacinto River basin (Lake Houston). In general, aquatic invasive species (except for the zebra mussel and giant salvinia) are found in the San Jacinto River basin (the receiving basin) and the lower Trinity River basin downstream from Lake Livingston (the source basin). Invasive flora and fauna in the proposed CRPS area is focused on two species: giant salvinia (*Salvinia molesta*) and zebra mussel (*Dreissena polymorpha*). Mitigation for giant salvinia is discussed in Chapter 4; mitigation for zebra mussels is summarized in Chapter 4 and discussed in detail below.

#### 6.8.1.1.1 Zebra Mussel

Zebra mussel is a non-native freshwater bivalve introduced into the Great Lakes in the mid-1980s. It has since spread throughout the Great Lakes Basin and the Mississippi River drainage system, and is extending to the west across the mountains. It is a prolific aquatic nuisance species which the Secretary of the Interior has designated as *injurious wildlife*.

The zebra mussel is a highly invasive aquatic species that rapidly multiplies. It was identified in Lake Texoma in the upper Trinity River basin. Unconfirmed reports have also identified the downstream Lake Lavon as a reservoir that may also be affected by the zebra mussel. The Denison Dam on Lake Texoma and appurtenant structures are owned by the federal government and are operated by the USACE, Tulsa District. Invasive species controls have been implemented to limit zebra mussels' spread in the reservoirs under investigation (Lake Texoma and Lake Lavon).

The Texas Parks and Wildlife Department (TPWD) is also working with local, state and federal agencies, reservoir controlling authorities and water districts to develop a plan for dealing with this latest invasive threat to Texas waters. During sampling activities conducted in October 2009, no evidence of an active zebra mussel population could be confirmed in Lake Lavon, downstream from Lake Texoma on the Oklahoma-Texas boundary. USACE and TPWD are continuing to monitor these organisms in areas downstream from Lake Texoma, where they were discovered during 2009. Zebra mussel management could supplement identified design criteria, and may be achieved through invasive species management and adaptive measures, as necessary.

The zebra mussel's migration from watershed-to-watershed is thought to occur by transporting small-craft boats over land. This may also account for the quagga mussels' migration. Presently, no zebra mussels have been found in Lake Houston. Zebra mussel populations foul water intakes and reduce native biodiversity. Provided the zebra mussel has not already been introduced into the San Jacinto River watershed prior to constructing the LBITP, the proposed water conveyance canal could potentially be a conduit for transferring zebra mussels from the Trinity River to Lake Houston. After zebra mussels have invaded a system, little can be done to prevent its natural dispersion. Attempts to subsequently manage this species may be the only functional option available.

Young mussels, or veligers, are microscopic organisms that disperse, are carried on water currents and can easily pass through intake screens to colonize other areas. The mussels may also be introduced into other water bodies by the movement of boats and other watercraft from one lake, river, or reservoir to another. Zebra mussels attach themselves to solid objects, even other mussels, with adhesive byssal threads. This allows them to produce thick colonies, which can become so dense they interfere with intake and conveyance in water systems, and adversely impact aquatic ecosystems.

Measures to control zebra mussels include biological, physical, and chemical treatments. Biological treatments include bacteria, natural predators, parasites, and diseases. Using biocides to control zebra mussels is controversial. To date no known biological method has proven to be effective in controlling this invasive species, due to its ability to proliferate, adapt and move within watersheds. A bacterial toxin has been discovered that is lethal (approximately a 98 percent kill rate) to zebra mussels, but it is harmless to non-target organisms and humans. However, more research and development for this technology is needed, although the Bureau of Land Management has approved it for application.

Physical treatments include electrical current, ultraviolet light, low-oxygen conditions, hydraulic isolation barriers, thermal and coatings. Physical treatments are often difficult to implement or are unproven for large-scale operations. Treatment may be effective in the immediate area of the physical method used, but may not prevent mussels from setting downstream from the device. Thermal back flushing of water intake pipes with heated water has been used to control zebra mussel, but a heated water source must be available. Slippery polymer-based or metal surface coatings such as zinc, copper, silver or mercury may interfere with the zebra mussels' ability to attach to coated objects; however, using silver may be cost prohibitive and using mercury would likely be unacceptable due to the adverse environmental effects. Coatings may also be impractical due to the extended down time for dewatering to apply the coating, and non-coated piping or surfaces downstream would not receive protection. Mechanical removal by scraping or water blasting could be considered, but if a watershed is already infested with zebra mussels, the treatment would likely be temporary.

Chemical treatments include the using oxidizing, non-oxidizing, and metallic molluscicides. Most implemented control technologies are chemical treatments, with oxidizing chemicals (chlorine and non-chlorine based) being prevalent. However, disinfection byproducts in the water supply systems have highlighted the importance of alternative technologies with reduced potential for byproduct formation. A limiting factor is that adult mussels sense the presence of halogen-based chemicals and close for days or weeks, thereby reducing the treatment's effectiveness. Non-oxidizing chemical treatments generally include organic ammonium compounds, herbicides and pesticides, some of which are prohibited for use in drinking water supply systems. Another treatment option is using metal ion solutions, generally copper ion, applied at water system intakes and other system components. The copper concentration is adjusted based on the flow rate within the system. Application results indicate this may be a viable treatment option to control zebra mussels.

The Applicant is keenly aware the zebra mussel is an aggressive, prolific species able to foul water supply structures and impact aquatic ecosystems. Presently, no zebra mussels have been found in Lake Houston or in the lower reaches of the Trinity River. Through natural dispersion and incidental transfer from human activities, the zebra mussel may be introduced into the San Jacinto or Trinity River watersheds prior to constructing the LBITP. Regardless, the Applicant will consider zebra mussel control options in LBITP's design phase, and will incorporate control and treatment methods into the management plan for operating and maintaining the LBITP.

Mitigation measures for the zebra mussel may include establishing monitoring procedures at the 11 stations examined in the San Jacinto and Lower Trinity River watersheds along with stations in Lake Conroe, Lake Livingston, and Lake Houston (McMahon 2012). **Appendix XX** includes the Luce Bayou Interbasin Transfer Project Zebra Mussel Control Plan, which outlines methods for the reduction of potential impacts if and when zebra mussels become a problem for the LBITP. An effective plan would include a multi-barrier approach using a variety of control measures at different facility locations.

# 7 Agencies, Organizations, and Persons to Whom Statement Copies Are Sent

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# 7.0 AGENCIES, ORGANIZATIONS, AND PERSONS TO WHOM STATEMENT COPIES ARE SENT

## 7.1 Agencies

The Luce Bayou Interbasin Transfer Project (LBITP) Section 404 Individual Permit (IP) application is being reviewed by the U.S. Army Corps of Engineers (USACE), Galveston District, pursuant to Section 10 of the Rivers and Harbors Act of 1899, and Section 404 of the Clean Water Act (USACE, Galveston District (SWG) 2009-00188). The proposed LBITP would directly impact greater than three acres of state waters or 1,500 linear feet of streams and would therefore not meet Texas Commission on Environmental Quality's (TCEQ) Tier I criteria for the project. Therefore, TCEQ Section 401 water quality certification is required. Concurrent with SWG processing the Section 404 Individual Permit (IP) application, the TCEQ is reviewing this application under Section 401 of the Coastal Water Authority (Authority) and in accordance with Title 30, Texas Administrative Code Section 279.1-13 to determine if the work would comply with state water quality standards.

SWG reviewed the Section 404 IP application, the Section 404(b)(1) Alternatives Analysis, the Environmental Report submitted by the Applicant and relevant National Environmental Policy Act (NEPA) statutes for a Department of the Army (DA) permit, and the list of factors outlined by 40 CFR 1508.27(b) to determine whether an Environmental Impact Statement (EIS) would be needed. Central to deciding whether an EIS would be required is determining if the proposed action would have significant effect on the quality of the human environment. To make this decision, SWG reviewed the list of factors regarding intensity in the context of the region affected by the proposed LBITP, specifically the Trinity River and Lake Houston, for short-term and long-term effects. Based on the review and after evaluating factors related to intensity and context from potential effects from the proposed LBITP and stated views from other interested federal and non-federal agencies and the concerned public relative to the proposed work in waters of the U.S., including wetlands, SWG determined the LBITP as proposed may have a significant effect on the human environment. In accordance with 33 CFR 325 Appendix B, Paragraph 7, SWG determined the proposed project requires an EIS be prepared. Further investigation into those areas of potential significant impacts on the human environment are necessary to allow SWG to evaluate the Section 404 IP applicant, make the proper decision, and assist the Applicant to better address issues of concern during the proposed LBITP's final design phase.

A Draft Environmental Impact Statement (DEIS) for the proposed LBITP has been prepared under SWG's direction. Agencies who will receive copies of the DEIS are identified in **Table 7-1**.

**Table 7-1:**
**Agencies Who Will Receive Copies of this DEIS**

| Name | Affiliation |
|---|---|
| Jim Herrington | U.S. Environmental Protection Agency (EPA) |
| Moni Belton | U.S. Fish and Wildlife Service (USFWS) |
| Catherine Yeargan | USFWS |
| Stuart Marcus | USFWS Trinity River National Wildlife Refuge |
| Rebecca Hensley | Texas Parks and Wildlife Department |
| Robert Hansen | Texas Commission on Environmental Quality |

## 7.2 Organizations

The LBITP Public Notice was published on April 19, 2010, which initiated the public scoping process for the LBITP. All comments received from the public and agencies in response to the April 2010 Public Notice for the LBITP were considered by SWG during the DEIS preparation process. With respect to the public scoping process for the LBITP DEIS, SWG conducted the Public Scoping Meeting on Thursday, July 21, 2011. Of the comments made or tabulated, 26 percent focused attention on the need to provide detailed analysis from various perspectives on aquatic and terrestrial organisms including invasive species and their related habitat. Effects from instream flows and freshwater flows to Galveston Bay represent an additional nine percent of comments received. Other major issue areas receiving comment include the proposal's hydrological impacts, land use and property value impacts, followed by comments relating to climate change, erosion and sedimentation, and water supply and water quality considerations. Those organizations who responded during the initial Public Notice period or provided comments during the Public Scoping Meeting will be provided copies of the DEIS (**Table 7-2**).

**Table 7-2:**
**Organizations Who Will Receive Copies of this Statement**

| Name | Affiliation |
|---|---|
| Scott Jones | Galveston Bay Foundation |
| Brandt Mannchen | Sierra Club |
| Donald Ripley | Coastal Water Authority |

## 7.3 Individuals

Those individuals who responded during the initial Public Notice period or provided comments during the Public Scoping Meeting will be provided copies of the DEIS (**Table 7-3**).

**Table 7-3:**
**Individuals Who Will Receive Copies of this Statement**

| Name | Affiliation |
|---|---|
| Bruce Bodson | Individual |
| Richard Bumstead | Local Landowner |
| Paul Friesma | Professor-<br>Northwestern Univ. |

# 8 Preparers and Reviewers




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# 8.0 PREPARERS AND REVIEWERS

| Responsibility | Affiliation / Name | Degree and Experience |
|---|---|---|
| **U.S. Army Corps of Engineers EIS Team** | | |
| Regulatory Branch Chief | Fred L. Anthamatten | |
| Regulatory Assistant Branch Chief | Casey Cutler | |
| Attorney-Advisor Office of Counsel | Mark Lumen | |
| Regulatory Project Manager | Jayson M. Hudson | |
| **AECOM EIS Team (Third-party Contractor to U.S. Army Corps of Engineers)** | | |
| Project Director | Stephen Berckenhoff, PE, CFM<br>AECOM<br>Houston, TX | BS Civil Engineering<br>22 years' experience |
| Project Manager | Robert C. Esenwein, CEP<br>AECOM<br>Houston, TX | BA, MA, PhD (ABD)/CEP<br>36 years' experience |
| Assistant Project Manager | Kelly Krenz, PG<br>AECOM<br>Houston, TX | BS Geology<br>MS Geology/Geophysics<br>30 years' experience |
| Environmental Flows | David Parkhill, PE, D. WRE<br>AECOM<br>Austin, TX | BS and MS Civil Engineering<br>40 years' experience |
| Air Quality and Greenhouse Gases | Gregory Derevianko<br>AECOM<br>Camarillo, CA | BS Applied Physics<br>MS Atmospheric and Oceanic Sciences<br>5 years' experience |
| Greenhouse Gas Emissions | Howard Balentine, PE, CCM (certified consulting meteorologist)<br>AECOM<br>Camarillo, CA | BS Physics<br>ME Environmental Engineering<br>37 years' experience |
| Water Quality, Physical Environment | Patricia Parmley<br>AECOM<br>Houston, TX | MS Environmental Biology<br>13 years' environmental experience |
| Fishery Resources, Agricultural Overspray Aquatic Resources | Ralph Calvino, REM<br>AECOM<br>Houston, TX | BS Aquatic Biology<br>20 years' experience |
| Economics | Carol Hollaway<br>AECOM<br>Houston, TX | MS Sociology<br>35 years' experience |
| Socioeconomic GIS-based Data Analyses and Manipulation | Lynn Chamberlain, EIT<br>AECOM<br>Houston, TX | BS and MS Biological & Agricultural Engineering<br>5 years' experience |
| Biological Resources, Wetlands | Roy Knowles, PWS<br>AECOM<br>Houston, TX | MS Wildlife and Fisheries Sciences<br>22 years' experience |
| Sediment/Wetlands Sampling | Lyndsay Massey<br>AECOM<br>Houston, TX | BS Environmental Science<br>8 years' experience |

| Responsibility | Affiliation / Name | Degree and Experience |
|---|---|---|
| Wetlands Impact Assessment | Timothy Love, PWS<br>AECOM<br>Houston, TX | BA Biology<br>MS Botany & Microbiology<br>22 years' experience |
| Pump Station Design | David Munn, PE<br>AECOM<br>Houston, TX | ME Civil Engineering<br>8 years' experience |
| Engineering (Canal) | Erin Williford, PE<br>AECOM<br>Houston, TX | BS Meteorology<br>MS Civil & Environmental Engineering<br>7 years' experience |
| Environmental Permitting | Mary L. Purzer, PE<br>AECOM<br>Houston, TX | BS Industrial Engineering<br>25 years' experience |
| Existing Conditions<br>Impact Assessment | Karen Kottke<br>AECOM<br>Houston, TX | BS Environmental Science & Chemistry<br>MS Environmental Science<br>12 years' experience |
| Existing Conditions<br>Impact Assessment | Devyn Richardson<br>AECOM<br>Houston, TX | BSc and MSc Range Management<br>14 years' experience |
| Project Accountant | Dorothy McFarlin<br>AECOM<br>Houston, TX | 19 years' experience |
| Geographic Information Systems (GIS) | Daomean Lim<br>AECOM<br>Houston, TX | BS Physics<br>32 years' experience |
| Benthic Aquatic Habitat Assessments and Characterizations | Brent Courchene, CFP<br>AECOM<br>Wakefield, MA | BS Biology<br>MS Marine Science<br>7 years' experience |
| Benthic Habitat and Mussel Characterizations | Ryan Robitaille<br>AECOM<br>Wakefield, MA | BS Wildlife & Fisheries Conservation<br>5 years' experience |
| Threatened and Endangered Terrestrial and Vegetative Species and Wetlands, Habitat Evaluation Procedures | Ryan Robol<br>Crouch Environmental Services, Inc.<br>Houston, TX | BS Biology<br>MS Environmental Studies<br>10 years' experience |
| | Matt Chastain<br>Crouch Environmental Services, Inc.<br>Houston, TX | BS Renewable Natural Resources<br>MS Natural Resources Development (in progress)<br>5 years' experience |
| | Susannah Scott<br>Crouch Environmental Services, Inc.<br>Houston, TX | BS Biology<br>MS Aquatic Resources<br>3 years' experience |
| | Austin Fitzgerald<br>Crouch Environmental Services, Inc.<br>Houston, TX | BS Biology<br>1 year experience |
| | Kay Crouch<br>Crouch Environmental Services, Inc.<br>Houston, TX | BS Biology<br>MS Biology/Aquatic Ecology<br>34 years' experience |
| | Greg Crouch<br>Crouch Environmental Services, Inc.<br>Houston, TX | BA Biology<br>MS Biology/Ecology<br>35 years' experience |

| Responsibility | Affiliation / Name | Degree and Experience |
|---|---|---|
| Wetlands Delineation, Verification, Archeological Oversight | David Young<br>Dixie Environmental Services, LP<br>Magnolia, TX | BS Marine Biology<br>18 years' experience |
| | Gary Kowalski<br>Dixie Environmental Services, LP<br>Magnolia, TX | BS Sociology<br>12 years of experience |
| Wetlands Delineation, Verification | Ally Freer<br>Dixie Environmental Services, Co., LP<br>Magnolia, TX | BS Environmental Science<br>5 years' experience |
| | Misti Little<br>Dixie Environmental Services, Co., LP<br>Magnolia, TX | BS Marine Biology<br>8 years' experience |
| Phase I ESA; HTRW | Ed Hawkinson, PG, CAPM<br>HVJ Associates<br>Houston, TX | BS and MS Geology<br>MBA Finance<br>34 years' experience |
| Archeological Resources | Roger Moore, PhD<br>Moore Archeological Consultants, Inc.<br>Houston, TX | PhD Anthropology<br>39 years' experience |
| | W. David Driver, PhD<br>Moore Archeological Consultants, Inc.<br>Houston, TX | PhD Anthropology<br>25 years' experience |
| | J. Randall Ferguson<br>Moore Archeological Consultants, Inc.<br>Houston, TX | BA Anthropology<br>30 years' experience |
| Zebra Mussels | Robert McMahon, PhD<br>Professor Emeritus<br>University of Texas at Arlington<br>Arlington, TX | PhD Marine Sciences<br>33 years' experience |
| Real Estate Acquisition, Engineering | Sudheer K. Rajavarapuu, PE<br>Isani Consultants, Inc.<br>Houston, TX | MS Civil Engineering<br>4 years' experience |
| Trinity River Hydrology | Jonathan Phillips, PhD<br>Department of Geography<br>University of Kentucky<br>Lexington, KY | PhD Geography<br>25 years' of experience |
| Administrative Consultant | Debbie George<br>TCI Construction<br>Houston, TX | MA Government/History<br>23 years' experience as a paralegal |

# 9 Scoping Summary




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# 9.0 SCOPING SUMMARY

## 9.1 Previous Scoping Activities

The public involvement and scoping process for the Luce Bayou Interbasin Transfer Project (LBITP) project was initiated when U.S. Army Corps of Engineers (USACE), Galveston District received the Department of the Army individual permit application for the LBITP. The LBITP was assigned Department of the Army Permit Application No.SWG-09-00188. The LBITP Public Notice was published on April 19, 2010, which initiated the public scoping process for the proposed project.

A Joint Evaluation Meeting for the LBITP was held between stakeholder agencies and USACE on February 10, 2010. Prior to that meeting, approximately 36 resource and/or regulatory agency meetings were held by the Applicant to provide project information and solicit agency comments concerning the proposed project. These meetings were held with staff from:

- U.S. Army Corps of Engineers (USACE)
- U.S. Environmental Protection Agency (USEPA)
- U.S. Fish and Wildlife Service (USFWS)
- Trinity River National Wildlife Refuge (TRNWR)
- U.S. Geological Survey (USGS)
- U.S. Department of Agriculture (USDA)
- Natural Resources Conservation Service (NRCS)
- Farm Service Agency
- Texas Commission on Environmental Quality (TCEQ)
- Texas Parks and Wildlife Department (TPWD)
- Texas Water Development Board (TWDB)
- Harris County Flood Control District

These agencies and other stakeholders have provided information related to project concerns, suggestions and approvals of approaches taken for resource evaluation and avoidance, habitat function and value assessment, and mitigation planning.

### 9.1.1 2010 Public Notice Comments Status or Use

All comments received from the public and agencies in response to the April 2010 Public Notice for the LBITP were considered by Corps, Galveston District during the Environmental Impact Statement's (EIS) preparation process. See **Section 3** of the complete Scoping Report in **Appendix T**.

## 9.2 2011 Public Scoping Meeting Summary

USACE conducted the LBITP Public Scoping Meeting on Thursday, July 21, 2011, from 5:30 p.m. to 8 p.m. at the Dayton Community Center, 801 South Cleveland, Dayton, Texas. See Section 2 of **Appendix T** for the meeting's agenda. American sign-language (ASL) and Spanish translators were available at the meeting for anyone needing translation assistance.

The scoping meeting included a workshop format with stations established by various project, NEPA and EIS process description board displays from 5:30 p.m. to 7:00 p.m., a 15-minute formal presentation by the USACE followed by the public comment period. USACE and contractor representatives were available at each station to answer questions about the project and the EIS process.

### 9.2.1 Attendees

Forty-three persons attended the Public Scoping Meeting including applicant representatives, public stakeholders, adjacent property owners, and some from public agencies. Southwest Galveston District's Commander Colonel Christopher Sallese conducted the meeting. He was supported by USACE' staff members: Casey Cutler, Assistant Regulatory Branch Chief; Isidro Reyna, Public Affairs Specialist; Pam Thibodeaux, Head Registrar; Jayson Hudson, Project Manager, and Mark Lumen, Attorney-Advisor, Office of Counsel.

Meeting attendees were invited to submit comments about the proposed project through July 29, 2011, the commenting period's official end. Comments were submitted to the USACE' Project Manager Jayson Hudson via:

- Registered verbal comment,
- Facsimile message,
- U.S. Postal Service, and
- Electronic mail or e-mail.

In addition to signing in at the registration table, attendees were provided a comment handout sheet and a speaker card to complete and return during the meeting (see **Appendix T** for the completed sheets/cards). The speaker cards indicated if the attendee desired to make a public comment at the meeting. Throughout the meeting, Colonel Sallese asked for input from attendees. An attendees list is included in the Public and Agency Comments section of this report as part of the meeting transcript.

### 9.2.2 Speakers

Three individuals gave public comments at the meeting: affected property owners Fred Masters and Richard Bumstead, and Houston Sierra Club representative Brandt Mannchen. Speakers were permitted to speak as long as they wanted, but no one spoke more than five minutes. See **Section 2.3.2** of **Appendix T** for the public comments.

### 9.2.3 Displays, Handouts and Photographs

A number of 30-inch by 40-inch displays and exhibits were presented at the Public Scoping Meeting along with several handouts. See **Section 2.3.3** of **Appendix T** which includes copies of materials presented at the meeting.

### 9.2.4 Advertisements and Publicity Coverage

The legal advertisement for the LBITP Public Scoping Meeting was published on July 21, 2011, in the following newspapers on the dates listed. **Section 2.3.4** of **Appendix T** includes copies of the newspaper notices, publication affidavits, and USACE website notice. Photographs from the meeting and post-event publicity are in **Appendix T**.

- The Liberty Gazette (July 5, 2011)
- Houston Chronicle (July 6, 2011)
- Dayton News (July 6, 2011)
- Cleveland Advocate (July 6, 2011)
- Eastex Advocate (July 6, 2011)
- The Lake Houston Observer (July 7, 2011)

- Liberty Vindicator (July 7, 2011)
- *La Voz* (July 10, 2011)

The Public Scoping Meeting Notice was translated into Spanish and published on July 10, 2011 in the Spanish language newspaper *La Voz*, which is published in the Sunday Houston Chronicle.

### 9.2.5 Meeting Announcements and Distribution Lists

In addition to the Public Notices, a Public Scoping Meeting announcement was mailed to over 300 residences on June 29, 2011 and area churches on July 6, 2011, using U.S. first-class mail. The Public Scoping Meeting announcement (i.e., flyer) was followed up with a post card reminder that included the meeting location map. **Appendix T** includes copies of the meeting mail pieces and distribution lists.

## 9.3 Comment Summary

USACE received verbal, written, and electronic comments during the scoping comment period. The commenting period was initiated when the NOI was published in the Federal Register on May 25, 2011. Comments were received after publishing the Public Notice in 2010, during the Public Scoping Meeting as recorded and transcribed in the meeting transcript, and during the Commenting Period after issuing the NOI in the Federal Register on May 25, 2011 and ending July 29, 2011. **Table 9-1** summarizes the 224 substantive comments recorded and transcribed. Written comments were received during and after the Public Scoping Meeting on comment forms provided to the public during the meeting and in letters provided to USACE following the meeting.

**Table 9-1:**
**LBITP Comment Categories**

| Number of Comments | Comment Category |
|---|---|
| 21 | NEPA/EIS Sections 404 and 10 Permit Processes |
| 1 | Public Involvement |
| 9 | Project Description/Definition |
| 9 | Alternatives, including No Action |
| 24 | Impact Assessment Methodology/Cumulative Effects Analysis |
| 14 | Facility Considerations (Construction, Operation, Maintenance) |
| 16 | Sustainability or Quality of Life |
| 5 | Water Supply/ Water Quality |
| 25 | Wetlands/Wetland Mitigation |
| 11 | Hydrology |
| 6 | Climate Change |
| 28 | Aquatic/Terrestrial Species and Assorted Habitat Impacts |
| 12 | Invasive Species |
| 6 | Surface Water Resources |
| 1 | Threatened and Endangered Species |
| 2 | Floodplains/Riparian Habitat |
| 7 | Erosion/Sedimentation |
| 13 | Instream Flows/Freshwater Inflows |

| Number of Comments | Comment Category |
|---|---|
| 5 | Interbasin Transfer/Ecological Considerations |
| 9 | Land Use/Property Values |
| **224** | **Total Substantive Comments** |

Potential effects associated with the proposed LBITP provided in a detailed analysis in the EIS are likely to include, but may not be limited to:

- Potential direct effects to waters of the U.S., including wetlands;
- Water quality;
- Aquatic species;
- Air quality;
- Environmental justice;
- Socioeconomic environment;
- Archaeological and cultural resources;
- Recreation and recreational resources;
- Energy supply and natural resources;
- Hazardous waste and materials;
- Aesthetics;
- Public health and safety;
- Navigation;
- Erosion and accretion;
- Invasive species;
- Cumulative impacts;
- Public benefit and needs of the people, and
- Potential effects on the human environment.

These and other public interest review factors identified by 33 CFR §320.4 are evaluated in the EIS.

Written and electronic comments were provided to Mr. Jayson Hudson, Project Manager, U.S. Army Corps of Engineers, P.O. Box 1229, Galveston, Texas 77553 by mail or facsimile transmission or could be submitted via e-mail to Jayson.M.Hudson@usace.army.mil until the end of the public comment period established as June 30, 2011. By the end of the public comment period, 224 total substantive comments were received and have been organized into 20 major categories based on the comment's nature and type. Of the comments made or tabulated, 26 percent focused on the need to provide detailed analysis from various perspectives on aquatic and terrestrial organisms including invasive species and their related habitat. Adding to these the comments related to the effects from instream flows and freshwater flows to Galveston Bay raises this to 35 percent focused on aquatic and terrestrial organisms. Other major issue areas receiving comments include the proposal's hydrological impacts, land use and property value impacts, followed by comments relating to climate change, erosion and sedimentation, and water supply and water quality considerations.

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# 11 Glossary




2012

US Army Corps
of Engineers
Galveston District

# Contents

# 11.0 Glossary

## A

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|---|---|
| **Administrative Record** | A comprehensive file of documents that forms the basis of decisions made for the project required by law. |
| **Aeolian** | Wind's ability to shape the surface of the earth. |
| **Affected environment** | Existing biological, physical, social, and economic conditions of an area subject to change, both directly and indirectly, as a result of a proposed human action. |
| **Algae** | Simple rootless plants that grow in sunlit waters in proportion to the amount of available nutrients. They can affect water quality adversely by lowering the dissolved oxygen in the water. They are food for fish and small aquatic animals. |
| **Alternative** | One of a number of options identified in an environmental impact statement for study and analysis of impacts and benefits. Following detailed analysis, one alternative is selected for implementation. |
| **Anadromous fish** | Fish that migrate up river from the sea to breed in freshwater. |
| **Anthropogenic** | Coming from human sources, relating to the effect of man on nature. |
| **Anurans** | Order of amphibians including frogs and toads. |
| **Aquatic ecosystem** | Community of biological organisms dependent on each other and the environment in a body of water. |
| **Aquifer** | An underground layer of water-bearing sediment (rock, gravel, sand, silt or clay) from which groundwater can be extracted using a well. |
| **Archaeological interest** | Capable of providing scientific or humanistic understanding of past human behavior, cultural adaptation, and related topics through the application of scientific or scholarly techniques. |
| **Archaeological resource** | Any material remains of human life or activities that are at least 50 years of age and that are of archaeological interest. |
| **Area of interest or influence** | Used to prescribe the geographic extent that is being evaluated for a particular resource which may vary among resources. This term is often used in association with the consideration of project or cumulative impacts. |

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| **Aroclor 1016** | Type of PCB (polychlorinated biphenyl). |
| **Aromatic** | Applied to a class of organic compounds containing benzene rings or benzenoid structures. |
| **Assimilative capacity** | The capacity of a natural body of water to receive wastewater or toxic materials without harmful effects and damage to aquatic life and to humans who consume the water. |
| **Attainment area** | An area that the Environmental Protection Agency has designated as being in compliance with one or more of the Nation Ambient Air Quality Standards (NAAQS) for sulfur dioxide, nitrogen dioxide, carbon monoxide, ozone, lead, and particulate matter. An area may be in attainment for some pollutants but not for others |
| **Austroriparian** | (Blair 1950) Austroriparian province extends into eastern Texas and occupies a strip of coastal plain from the Gulf of Mexico to the Ouachita Mountains of Oklahoma. The plants and animals of this province are mostly species that extend eastward on the coastal plain to the Atlantic. |

# B

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| **Bacteria** | Single-celled organisms that do not contain a membrane-bound nucleus. Some bacteria cause disease and others are important in stabilization of organic wastes. |
| **Baseline** | The existing environmental conditions against which impacts of the proposed action and its alternatives can be compared.. |
| **Bathymetric Survey** | The science of making essential measurements of water depths in oceans, lakes and seas. |
| **Benthos** | Organisms associated with the sediment-water interface. |
| **Berm** | A relatively narrow, horizontal or gently sloping man-made bench or shelf which is generally part-way up a slope such as a road shoulder. |
| **Biochemical Oxygen Demand (BOD)** | The amount of oxygen required during decomposition of organic matter in a body of water. |
| **Biological assessment** | An evaluation of potential effects of a proposed project on proposed, endangered, threatened, and sensitive animal and plant species and their habitats. Information prepared by, or under the direction of, a Federal agency to determine whether a proposed action is likely to adversely affect listed species or designated critical habitat; jeopardize the continued existence of species that are proposed for listing; or adversely modify proposed critical habitat. |

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| **Biological opinion** | An appraisal from either the Fish and Wildlife Service (FWS) or the National Marine Fisheries Service (NMFS) evaluating the impact of a proposed Federal action, if it is likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat, as required by Section 7 of the Endangered Species Act. |
| **Bivalves** | A mollusk with two-hinged shells belonging to the class Bivalvia (e.g. oysters, clams, and scallops). |
| **Bottomlands** | Low-lying alluvial land near a lake or stream. |
| **Brackish** | Water with a salinity lower than that of seawater; seawater and freshwater mixed; typical of estuarine environments. |
| **By-catch** | The incidental catch of one species during pursuit of another, the term is often applied to species of fish and shellfish captured incidentally by commercial fishing and shrimping operations. |

# C

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| **Calcareous** | Containing calcium carbonate or limestone; chalky. |
| **Candidate species** | A species of plant or animal for which there is sufficient information to indicate biological vulnerability and threat, and for which proposing to list as “threatened” or “endangered” is or may be appropriate. |
| **Carrying capacity** | The maximum population of a particular species that can exist in a given habitat without hindering future generations’ ability to maintain the same population. |
| **Clayey** | Soil dominated by tiny clay particles. |
| **Coastal wetlands** | Forested and nonforested habitats, mangroves, and all marsh islands which are exposed to coastal waters. These areas directly contribute to the high biological productivity of coastal water by input of detritus and nutrients, by providing nursery and feeding areas for shellfish and finfish, by serving as habitat for many birds and other animals, and by providing waterfowl hunting and fur trapping. |
| **Coastal zone** | A transition zone where the land meets water. Extends offshore to the continental shelf break and onshore to the first major change in topography about the reach of major storm waves. |
| **Coastal zone consistency review** | State review of direct Federal activities or private individual activities requiring Federal licenses or permits, and OCS plans pursuant to the CZMA to determine if the activity is consistent with the enforceable policies of the State’s federally approved CZM program. |

**Consultation** Exchange of information and interactive discussion; can be mandated when referencing mandate by statute or regulation that has prescribed parties, procedures and timelines.

**Cordgrass** Any member of the genus, Spartina; a partially submerged wetland plant common to brackish and salt marshes of the Gulf Coast.

**Council on Environmental Quality (CEQ)** An advisory council to the President of the United States established by the National Environmental Policy Act of 1969. It reviews Federal programs for their effect on the environment, conducts environmental studies, and advises the president on environmental matters.

**Critical habitat** A designated area that is essential to the conservation of an endangered or threatened species that may require special management considerations or protection.

**Crustacean** A group of aquatic animals characterized by jointed legs and a hard shell which is shed periodically, which includes shrimp, crabs, barnacles, and lobsters.

**Cultural resources** Archeological and historic resources that could potentially be affected by a given project. Includes buildings, sites, districts, structures, and objects having historical, architectural, archeological, cultural or scientific importance.

**Cumulative effect** The impact on the environment that results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions.

# D

**Day/night sound level** The average noise level over a 24 hour period.

**Decibel (dB)** A unit for expressing the relative intensity of sounds on a logarithmic scale from zero for the average least perceptible sound to about 130 for the average level at which sound causes pain to humans.

**Deciduous Forest** Forest where the majority of trees lose foliage at the end of the typical growing season.

**Desilting** Removal of suspended silt from water.

**Dewater** To remove available groundwater from an aquifer by pumping in excess of recharge capability.

**Diapir** Structure of mobile material forced into more brittle surrounding rocks by upward flow of material from parent stratum. Often associated with salt domes.

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| **Dioxin** | Any of a family of compounds known chemically as dibenzo-p-dioxins. A chlorinated organic chemical that is highly toxic. |
| **Direct effects** | The effects of an action which are caused by the action and occur at the same time and place. |
| **Discharge** | Volume of water per unit of time flowing along a pipe or channel. Commonly measured in cubic feet per second (cfs). |
| **Dissolved Oxygen (DO)** | A measure of the amount of oxygen dissolved in water necessary for respiration of most aquatic organisms. |
| **Dredged Material** | Sediment or rock that is excavated or dredged from waters of the United States such as access canals, boat or navigation channels, drainage ditches and lakes. The dredged materials are moved to a disposal location. |
| **Dredge-and-fill activity** | Removal and subsequent discharge of dredged materials such as mud and sediments from the bottom of waterbodies, including wetlands. This can disturb the ecosystem and causes silting that can kill aquatic life. |

# E

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| **Ecological** | Encompasses the habits of a species; the way a species relates to, or fits in with, its environment; where it lives, what it consumes, and how it avoids predators or displacement by other species. |
| **Ecology** | A branch of science dealing with the interrelationships of living organisms with one another and with their nonliving environment. |
| **Ecosystem** | The living organisms and nonliving environment interacting in a given area. Encompasses relationships between biological, geochemical, and geophysical systems. |
| **Effects (impacts)** | Environmental change resulting from a proposed action. Direct effects are caused by the action and occur at the same time and place, while indirect effects are caused by the action but are later in time or further removed in distance, although still reasonably foreseeable. Indirect effects may include growth-inducing effects and other effects related to induced changes in the pattern of land use, population density, or growth rate, and related effects on air and water and other natural systems, including ecosystems. Effect and impact are synonymous. |
| **Effluent** | Any water flowing from a confined disposal facility during and as a result of dredged material placement. |
| **Eligible property** | Property that meets the criteria for inclusion in the National Register of Historic Places but is not formally listed. |

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| **Emergent marsh** | Marshes in which vegetation is rooted underwater and the tops exposed (as contrasted with submerged vegetation or upland habitats). |
| **Endangered Species Act** | The federal law that governs how animal and plant species whose populations are dangerously in decline or close to extinction will be protected and recovered. The law protects not only threatened and endangered species, but also the ecosystems upon which they depend. |
| **Endangered and threatened species (endangered species)** | Plant or animal species that are in danger of extinction throughout all or a significant part of their range. |
| **Entrainment** | The intake of relative immobile, free-floating organisms with water drawn into an industrial, municipal, or electric utility power plant. |
| **Environmental assessment** | A planning report which represents the first thorough examination of alternative plans that positively demonstrates that environmental and social consequences were considered. |
| **Environmental baseline** | The past and present impacts of all Federal, State, or private actions and other human activities in an action area. |
| **Environmental consequences** | Environmental effects or impacts to an affected environment that are expected from the implementation of a given alternative. |
| **Environmental effect** | A measurable alteration or change in environmental conditions. |
| **Environmental Impact Statement (EIS)** | A full disclosure document required by federal environmental law that details the process through which a federal project was developed, determines the viability of the option, considers a range of reasonable alternatives, analyzes the potential impacts resulting from each alternative, and demonstrates compliance with other applicable federal environmental laws and executive orders. |
| **Ephemeral Stream-Flow** | A stream that flows only in direct response to precipitation, and whose channel is above the water table at all times. |
| **Essential habitat** | Specific areas crucial to the conservation of a species that may necessitate special considerations. |
| **Estuary** | A place where fresh and salt water mix, such as a bay, salt marsh, or where a river enters an ocean. Where currents are met and affected by tidal action. |
| **Exotic species** | Includes species introduced into an area that may have adapted to the area and compete with resident native (indigenous) species of plants and animals (e.g. grass carp, Chinese tallow tree) often established purposefully or inadvertently by human activity. |

**Executive Order (EO)** Official proclamation issued by the President that may set forth policy or direction or establish specific duties in connection with the execution of federal laws and programs. A government order having the force of law.

# F

**Facies** Body of sedimentary rock distinguished from others.

**Fauna** The vertebrate and invertebrate animals of a region.

**Federal undertaking** An undertaking is any Federal project, activity, or program that involves the expenditure of Federal money and be under the direct or indirect jurisdiction of a Federal agency..

**Floodplains** The lowlands and relatively flat areas adjoining inland and coastal waters and the flood-prone areas of offshore islands. Floodplains include, at a minimum, that area with at least a 1.0 percent chance of being inundated by a flood in any given year. The *base floodplain* is defined as the 100-year (1.0 percent) floodplain. The *critical action floodplain* is defined as the 500-year (0.2 percent) floodplain.

**Food chain** A series of interconnected feeding relationships; the process of energy capture (by green plants) and successive transfer to grazers (primary consumers) and predators (secondary consumers and above).

**Freeboard** The vertical distance between the water level and the top of a structure.

**Fresh water marsh** An area of shallow freshwater covered with grass, cat tails and other grasses.

**Freshwater inflow** The flow of fresh water into the bay system from its watershed.

**Fringing wetland** Wetlands found at the periphery of a bay, typically brackish or salt marsh found along shorelines protected from strong wave action.

# G

**Geosyncinel** Basinlike depression along the edge of a continent in which thick sequence of sediment and volcanic deposits has accumulated.

**Geographic Information System (GIS)** A computer system capable of storing, analyzing, and displaying data and describing places on the earth's surface.

**Glochidia** Larva of freshwater mussel living as a temporary parasite in gills or other external parts of fish.

**Groundwater** Water found below the earth's surface, such as in an aquifer. Source of water for wells, seeps and springs.

# H

**Habitat** The natural and physical location in which a population of plants and animals live. A sum of environmental conditions in a specific place that is occupied by organisms, population or a community.

**Harass/Harassment** An intentional or negligent act or omission that creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavior patterns that include, but are not limited to, feeding or sheltering.

**Harm** An act which may include significant habitat modification or degradation where it actually kills or injures wildlife by impairing essential behavior patterns, including breeding, feeding, or sheltering.

**Historic property** Resources of national, state, or local significance in American history, architecture, archeology, engineering, or culture, and worthy of preservation.

**Human environment** Interpreted comprehensively to include the natural and physical environment and the relationship of people within that environment.

**Hydrograph** A graph showing, for a given point on a stream or a channel, the discharge, water surface elevation, stage, velocity, available power, or other property of water with respect to time.

**Hydrologic cycle** The continuous cycling of water in the biosphere as solid, liquid, and gas; water evaporates from oceans to the atmosphere and is returned to the ocean via precipitation and river flow.

**Hydrology** Scientific study of the properties, distribution, and effects of water on the surface, soil, rock, and atmosphere. Includes groundwater, surface water, and rainfall.

**Hydrophytic vegetation** Growing wholly or partially in water or having or characterized by excessive moisture. Plant life that thrives in wetlands or wet conditions.

**Hydrostatic** Fluid or liquid at rest or in equilibrium and pressure being exerted.

**Hypothermia** Subnormal temperature of the body, usually due to excessive heat loss.

**Hypoxia** Depressed levels of dissolved oxygen in water, usually resulting in decreased metabolism.

# I

**Impacts**

Environmental consequences (the scientific and analytical basis for comparison of alternatives) as a result of a proposed action. An assessment of the meaning of changes in all attributes being studied for a given resource; an aggregation of all the positive or negative effects, usually measured using a qualitative and nominally subjective technique. The term impact is used synonymously with the term effect.

**Impervious surface**

A hard surface area such as roads, parking lots, and roofs, whose properties prevent infiltration of water and increase the amount of storm water runoff in a watershed.

**Inadvertent discovery**

The unanticipated encounter or detection of human remains, funerary or sacred objects, or objects of cultural patrimony found under or on the surface of Federal or tribal lands.

**Incidental take**

Take of a threatened or endangered fish or wildlife species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by a Federal Agency or applicant (see take).

**Illicit discharge**

A discharge to a storm sewer that is not composed entirely of storm water and is not authorized by a permit. Often caused by the unintentional discharge of domestic (human, household) wastewater via damaged wastewater collection systems, but also from intentional discharges of other wastes.

**Indian tribe**

Any tribe, band, nation, or other organized group or community of Indians, including any Alaska Native village (as defined in, or established pursuant to, the Alaska Native Claims Settlement Act), which is recognized as eligible for the special programs and services provided by the United States to Indians because of their status as Indians.

**Indicator species**

A species that, through its population size or condition, mirrors environmental conditions within an ecosystem.

**Indigenous**

Occurring naturally in a particular region or environment. Also referred to as "native."

**Indirect effects**

Effects caused by activities which are stimulated by an action but not directly related to it.

**Indirect impact**

Effects and impacts are used synonymously. Indirect impacts are caused by the action and are later in time or farther removed in action or distance, but are still reasonably foreseeable.

**Inflow**

The water flowing into a stream, lake, reservoir or bay during a specified period.

**Interbasin transfer**

The transfer of water from one river basin to another river basin for water supply purposes.

**Interferometry** Instrument using interference patterns to make measurements of waves.

**Intermittent** Alternately ceasing and beginning; not continuous.

**Intertidal** The zone between high and low water tides.

# L

**Lake** An inland body of standing water deeper than a pond, an expanded part of a river or a reservoir behind a dam. Does not include artificial lakes or ponds created by excavating and/or diking dry land to collect and retain water for such purposes as stock watering, irrigation, settling basins, cooling, or rice growing.

**Land use** A general term used to describe how land is or may be utilized or developed, whether for industrial, commercial, residential or agricultural purposes, or as open space.

**Larval** The earliest developmental form of a fish after hatching that is fundamentally unlike the mature form; the animal must metamorphose before assuming adult characters.

**Levee** A dike or embankment designed to prevent land from inundation or flooding.

**Loading** An influx of pollutants to a selected water body.

**Lyons Flows** General low-flow condition adequate to maintain sound ecologic function.

# M

**Macroinvertebrate** Large invertebrates found in streams and consisting largely of larval insects, worms and related organisms.

**Macrophyte** Visible aquatic plant growing in or near water such as sawgrass, sedges and lilies.

**Major Federal Action** An action significantly affecting the quality of the human environment must be evaluated with an EIS. Action includes new and continuing activities, including those financed, regulated or approved by federal agencies. Federal actions include adoption of official policy, formal plans, or programs and approval of specific projects.

**Mammal** The class of animals that are distinguished by having self regulating body temperature, hair, and in females, milk producing mammary glands to feed their young.

**Marshes** Tracts of soft, wet land, usually vegetated by reeds, grasses and small shrubs. A soft, wet area periodically or continuously flooded to a shallow depth, characterized by grasses, cattails and other low plants.

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| **Mesic Forest** | Hardwood forest adapted to moderately moist habitat. |
| **Metals** | Referring to "heavy metals": metallic elements with high atomic weights; (e.g. mercury, chromium, cadmium, arsenic, and lead); can damage living things at low concentrations and tend to accumulate in the food chain. |
| **Microbe** | Microorganisms such as bacteria, algae, diatoms, plankton, and fungi. |
| **Migratory** | Species that periodically pass from one region or climate to another for feeding or breeding. |
| **Mima Mounds** | A term used along the Gulf Coast of eastern Texas and southwestern Louisiana for one of hundreds of thousands of low, rudely circular or elliptical domes composed of loamy sand. Their diameter ranges from 3 meters to more than 30 meters and height ranges from 30 centimeters to more than 2 meters. |
| **Minority population** | A population that is classified by the U. S. Bureau of the Census as African American, Hispanic American, Asian and Pacific American, American Indian, Eskimo, Aleut, and other non-White persons, whose composition is at least 25 percent of the total population of a defined area or jurisdiction. |
| **Mitigation** | Reasonable measures taken to avoid, minimize, rectify, or compensate for impacts to the physical environment resulting from federal action. |
| **Mollusk** | Large group of unsegmented invertebrates that are largely marine including snails, clams, squids and octopus. |
| **Morphology** | A river/estuary/lake/seabed form and its change with time. |

# N

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| **National Ambient Air Quality Standards** (NAAQS) | Standards set by the Environmental Protection Agency for the maximum levels of certain pollutants that can exist in the outdoor air without unacceptable effects on human health or the public welfare. |
| **National Estuary Program** | A program established under the Clean Water Act Amendments of 1987 to develop and implement conservation and management plans for protecting estuaries and restoring and maintaining their chemical, physical, and biological integrity, as well as controlling point and nonpoint pollution sources. |
| **National Pollutant Discharge Elimination System (NPDES)** | Federal regulatory program requiring permits for the discharge of pollutants from any point source into the waters of the United States. |

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| **National Register of Historic Places** | A federal listing of historic properties such as districts, sites, buildings, structures, and objects of prehistoric or historic local, state or national significance protected under the National Historic Preservation Act of 1966. |
| **Natural resources** | The viable or renewable products of nature such as water, soil, and air. Included are plants and animals, nutrients, and other resources produced by the earth's natural processes. |
| **Neotropical** | Living and migrating within the region that includes South America, the West Indies and tropical North America. |
| **Non-attainment area** | An area that is shown by monitoring data or air-quality modeling calculations to exceed primary or secondary ambient air quality standards established by the U.S. Environmental Protection Agency. |
| **Non-Point Source (NPS)** | Discharge of pollutants into the water or air where the source comes from an area rather than a single pinpointed source. Extensive or disperse source of pollution. Examples include agriculture, lawns, parking lots and septic systems. |
| **Notice of Availability (NOA)** | An NOA is the Federal Register notice that announces the availability of a draft or final Environmental Impact Statement (EIS). |
| **Notice of Intent (NOI)** | A notice that an environmental impact statement will be prepared and considered. The notice shall briefly describe the proposed action and possible alternatives. |
| **Nutrient** | Elements or compounds essential to growth and development of living things such as carbon, oxygen, nitrogen, potassium and phosphorus. |
| **Nutrient cycle** | Chemical transformation of nitrogen, phosphorus and silica compounds in continuous cycles of organic and inorganic phases in an ecosystem. |
| **Nutrient Spiraling** | Passage of dissolved nutrients such as nitrogen being transported downstream. |

# O

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| **One hundred year flood plain** | Level of flood water expected to be equaled or exceeded every 100 years. Referenced as 1% annual exceedence probability flood, since 1% chance of being equaled or exceeded in a single year. |
| **Open-Bay bottom** | A bay habitat habitat, consisting of those areas of the bay bottom not covered with oyster reef or seagrass meadow. |
| **Open-Bay water** | A large volume of water consisting of many water masses having different salinity, and at times, oxygen and temperature, values. Also referred to as the "water column." |

**Ordinary high water mark** The line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas.

**Organic matter** Material derived from living plant or animal organisms.

**Organic pollutant** Pollutants containing carbon that persist in the environment, through the food web and pose a threat to human health and the environment due to their toxic effects. These pollutants include organochlorine pesticides.

**Organochlorine pesticide** Pesticides (generally insecticides) that are hydrocarbon compounds containing chlorine. They are not easily broken down and can persist in the environment for many years. Includes DDT, dieldrin, chlordane, and aldrin.

**Outfall** A structure extending into a body of water for the purpose of discharging sewage, storm run-off, or cooling water.

**Oyster reef** An ecosystem based on the formation of a three-dimensional structure from the growth of oyster shells.

# P

**Particulate matter (PM)** A complex mixture consisting of varying combinations of dry solid fragments, solid cores with liquid coatings, and small droplets of liquid. These tiny particles vary in shape, size and chemical composition, and can be made up of many different materials such as metals, soot, soil and dust.

**Parts per million (ppm)** The number of "parts" by weight of a substance per million parts of water. This unit is commonly used to represent pollutant concentrations.

**Perennial** A plant that lives for at least 2 or more years.

**pH** A measure of the relative acidity or alkalinity of a solution, expressed on scale from 0 to 14, with the neutral point at 7.0. Acid solutions have pH values lower than 7.0, and basic (i.e., alkaline) solutions have pH values higher than 7.0.

**Photosynthesis** The incorporation of solar energy into carbon compounds by green plants, chemically combining atmospheric carbon dioxide and water.

**Phytoplankton** Microscopic aquatic plants or single-celled algae suspended in the water column.

**Planktonic** Organisms floating in the water column.

**Point source pollution** Pollutants are discharged from a stationary location or fixed facility; any single identifiable source of pollution; e.g. a pipe, ditch, ship.

**Pollutant** Any introduced substance that adversely affects the usefulness of a resource or contaminates air, soil, or water.

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| **Polychaetes** | Segmented worms, mostly marine, bearing paddle-like appendages on the body segments which, in turn, carry numerous bristles. |
| **Population density** | The average number of people in a given unit area (e.g. number of people per square mile). |
| **Potential impact (effect)** | The range of alterations or changes to environmental conditions that could be caused by an action. |
| **Potentiometric level** | The level to which water rises in a well penetrating an aquifer. |
| **Preferred action** | The action that has been selected for implementation by the record of decision after consideration of purpose and need, project and cumulative impacts, and public comments.. |
| **Proposed action** | A plan that contains sufficient details about the intended actions to be taken, or that will result, to allow alternatives to be developed and its environmental impacts analyzed. |
| **Public comment/review period** | A proponent will make an EA and draft FNSI available to the public for review and comment for a minimum of 30 days prior to making a final decision and proceeding with an action. |
| **Public Hearing** | A public proceeding conducted for the purpose of acquiring information of evidence which will be considered in evaluating a proposed permit action or Federal project, and which affords the public an opportunity to present their views, opinions, and information on such permit actions or Federal projects. |
| **Public Interest** | Common well-being or general welfare. |
| **Purpose and need** | Purpose is a statement of goals and objectives that the action proponent intends to fulfill by taking action. The discussion should be limited to those goals and objectives that are critical to meet if the installation is to consider the proposal successful.<br><br>Need is a discussion of existing conditions that need to be changed, problems that need to be remedied, decisions that need to be made, and policies or mandates that need to be implemented. |

# Q

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| **Quaternary** | Most recent of three periods of Cenozoic Era; most recent 2.6 million years of Earth’s history. |

# R

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| **Recharge** | Process in which additional new water is added to an aquifer or to a zone of saturation. |
| **Record of Decision (ROD)** | A document prepared by the lead federal agency which outlines the decision and documents the required implementation and mitigation measures needed to complete a federally-funded or permitted project. |
| **Relative sea level rise** | The change in the position and height of sea relative to the land; determines the location of the shoreline. A rise in relative sea level may create or destroy coastal wetlands and salt marshes and induce salt-water intrusion into estuarine waters. Human actions including withdrawal of groundwater may to a local rise in relative sea level due to subsidence. |
| **Revetment** | A facing made of stone, concrete or other material to prevent erosion and/or collapse of an embankment or shoreline feature. |
| **Right-of-way** | A permit or easement which authorizes the use of public lands for certain specified purpose such as a transmission line, roadway or pipeline. |
| **Riparian** | Habitat along the shoreline or bank of a river, stream, lake or other waterbody. |
| **Rip rap** | A layer, facing, of protective mound of rubble or stones randomly placed to prevent erosion, scour, or sloughing of a structure or embankment. |
| **Risk analysis** | The assessment of total risk or hazards due to all possible environmental inputs and all possible mechanisms. |
| **Riverine** | A system of wetlands that includes all wetland and deep-water habitats contained within a channel that lacks trees, shrubs, persistent emergents, and emergent mosses or lichens. |
| **Rookery** | The nesting or breeding grounds of gregarious (i.e., social) birds or mammals; also a colony of such birds or mammals. |

# S

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| **Salinity** | A measure of salt concentration in marine waters. The number of grams of salt per thousand grams of sea water expressed in parts per thousand (ppt). |
| **Salt marsh** | A type of wetland or marsh periodically flooded by salt water. Herbaceous vegetation growing at saline intertidal elevation includes various grasses. |

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| **Salt Water Encroachment** | Intrusion of saltwater into subsurface aquifers previously occupied by freshwater. |
| **SB-1** | The 75th Texas Legislature's Senate Bill 1 (1997). |
| **Scope** | The range of actions, alternatives and impacts to be considered and required to complete a project. |
| **Scour** | The removal of underwater material by waves and current especially at the base or toe of a shore structure. |
| **Seagrass** | Members of marine seed plants that grow chiefly on sand or sand-mud bottom. |
| **Secondary impacts (see also indirect impacts)** | Those effects that are expected to be "caused" by the proposed action but are later in time or are removed in action or distance, but are still reasonably foreseeable. |
| **Section 106** | Provision in National Historic Preservation Act that requires federal agencies to consider effects of proposed actions on properties listed or eligible for listing in the National Register of Historic Places. |
| **Section 110 [National Historic Preservation Act]** | The heads of all Federal agencies shall assume responsibility for the preservation of historic properties which are owned or controlled by such agency. Prior to acquiring, constructing, or leasing buildings for purposes of carrying out agency responsibilities, each Federal agency shall use, to the maximum extent feasible, historic properties available to the agency in accordance with Executive Order No. 13006. |
| **Sediment** | Topsoil, sand, and minerals deposited by wind or water. |
| **Sedimentation** | Soil particles suspended in stormwater that can settle in streams and disrupt natural flow. |
| **Semi-volatile organic compound** | Operationally defined as a group of synthetic organic compounds that are solvent-extractable and can be determined by gas chromatography/mass spectrometry. SVOCs include phenols, phthalates, and polycyclic aromatic hydrocarbons (PAHs). |
| **Sensitive species (see also species at risk, species of concern)** | Plant or animal species susceptible or vulnerable to acitivity impacts or habitat alterations. Species that have appeared in the Federal Register as proposed for classification or are under consideration for official listing as endangered and threatened species. |
| **Sewage** | Waste matter from domestic or industrial establishments that is carried away in sewers or drains. |
| **Sewage bypass** | Discharge of untreated sewage directly to streams and the bay from wastewater treatment facilities typically due to heavy rainfall events where the capacity of the system is exceeded or the system malfunctions. |
| **Shellfish** | An aquatic invertebrate animal with a shell such as mollusks or crustaceans, e.g. shrimp and crabs. |

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| **Shoreline erosion** | Loss of the shoreline and associated vegetation due to natural causes such as wave action, storms, relative sea level rise, and bluff failure. Erosion can be exacerbated by man-made causes such as boat wakes, dredging, accelerated subsidence and shoreline modification. Results in the conversion of vegetated fringing wetlands to open water. |
| **Shoreline modification** | Modification, often detrimental, of shorelines by dredging, channelization and the placement of rip rap, bulkheads, seawalls and groins. |
| **Significant archaeological resource** | Those archaeological resources that meet the criteria of significance for eligibility to the National Register of Historic Places. |
| **Significant** | An action analyzed in the context of a proposed action and the severity of impacts/effects either beneficial or adverse; exists when effects on the quality of the environment are likely to be controversial. |
| **Siltation** | Deposition of soil particles moved by water caused by obstruction to flow and lower flow velocity. |
| **Species** | Any species or subspecies of fish or wildlife or plants (and in the case of plants, any varieties) and any distinct population segment of any species of vertebrate fish or wildlife which interbreeds when mature. |
| **Species of concern** (see also species at risk, sensitive species) | A species identified by a State, federal, local agency; the state heritage program, an NGO, or other organization, that is recognized to be in need of conservation management in order to maintain existing limited populations, distributions, or declining populations. |
| **Stakeholder** | An individual or organization with a "stake" in a natural resource or other issue by virtue of livelihood or simple personal interest. |
| **State Historic Preservation Officer (SHPO)** | The official within each State, authorized by the State at the request of the Secretary of the Interior, to act as liaison for purposed of implementing the National Historic Preservation Act. |
| **State Implementation Plan (SIP)** | A plan mandated by the Clean Air Act that contains procedures to monitor, control, maintain, and enforce compliance with the NAAQS. Produced by the state environmental agency. |
| **Storm sewer** | A system of pipes (separate from sanitary sewers) that carries water runoff from buildings and land surfaces. |
| **Storm water management program** | A program comprising six elements that, when implemented in concert, are expected to result in significant reductions of non-point source pollutants discharged into receiving waterbodies. The six elements are: (1) public education and outreach, (2) public involvement, (3) illicit discharge detection and elimination, (4) construction site runoff control, (5) post-construction runoff control and (6) pollution prevention. |

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| **Submerged Aquatic Vegetation (SAV)** | Rooted, submerged macrophytes, including seagrasses and freshwater rooted macrophytes; contrasts with emergent species such as smooth cordgrass. |
| **Subsidence** | Downward movement of the land surface resulting from consolidation of subsurface strata due to groundwater or petroleum withdrawal and natural settling. Groundwater withdrawal has been the most important contributor to subsidence for up to nine feet in the Galveston Bay region. |
| **Substrate utilization** | Underlying layer of material forming bed of stream for microorganism to remove contaminants. |
| **Subsurface reservoir** | Earth material such as rock near but not exposed at ground level and used to store water. |
| **Subtidal** | A region extending below intertidal to the edge of the continental shelf. |
| **Subwatershed** | A subdivision of a watershed based on hydrology, generally corresponding to the area drained by a small tributary or bayou, as opposed to a major river. |
| **Surface fault movement** | Natural phenomena associated with movement caused by subsidence. |
| **Surface Water** | Water that collects in a river, stream, lake, wetland or ocean. Surface water is naturally replenished by precipitation and naturally lost to evaporation. |
| **Swale** | A shallow depression in the land surface which may be filled with water. |
| **Swamp** | A type of freshwater wetland consisting of woodland or forested areas with saturated soils, which are inundated by water much of the year. Plant species include *Taxodium distichum* (baldcypress) and *Nyssa aquatica* (water tupelo). |

# T

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| **Tainter** | Gate used in dams and canal locks to control water flows |
| **Take** (in reference to Endangered Species Act) | To harass, pursue, hunt, harm, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct related to threatened or endangered fish or wildlife species. |
| **Taxon** | Group of organisms with common characteristics judged to be a unit. |
| **Terra mats** | Portable mats for use by heavy equipment; may be tailored to size of vehicle, road width, length or area or weight of equipment; allows short-term access with reduced impact by redistributing loads over larger area. |
| **Terrestrial** | Refers to earth or soil, as opposed to the aquatic or marine environment. |
| **Terrigenous clastics** | Sand, silt and clays resulting from weathering and erosion of rocks. |

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| **TexRiverism** | Statewide economic, hydrological, environmental and interbasin water transfer investment model. |
| **Threatened species** | Plant and wildlife species likely to become endangered species throughout all or a significant portion of its range within the foreseeable future. |
| **Total Maximum Daily Load (TMDL)** | The estimate of the total quantity of pollutants from all sources (point, non-point, natural) that may be allowed into waters without exceeding applicable water quality standards. |
| **Toxic** | Capable of causing death, disease, or birth defects in organisms. |
| **Texas Pollutant Discharge Elimination System (TPDES)** | The program with regulatory authority over discharges of pollutants to Texas surface water, with the exception of discharges associated with oil, gas, and geothermal exploration and development activities; administered by the TNRCC; authorized by the USEPA in September 1998. |
| **Tribal lands** | All lands within the exterior boundaries of any Indian reservation and all dependent Indian communities. |
| **Tributary** | A stream that contributes its water to another stream or body of water. |
| **Trophic** | Trophic refers to the hierarchy of organisms from photosynthetic plants to carnivores, such as man.(e.g., phytoplankton eaten by zooplankton eaten by fish). |
| **Trophic level** | The position in the food chain relative to eating and being eaten; including primary producers, primary consumers, and higher consumers. |
| **Turbidity** | Reduced water clarity or clearness resulting from the presence of suspended particles. |

# U

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| **Unavoidable adverse effects** | Effects that cannot be avoided due to constraints in alternatives. These effects do not have to be avoided by the planning agency, but they must be disclosed, discussed, and mitigated, if possible. |
| **Unionid** | Family of freshwater mussels with bilateral symmetry. |
| **Upland** | Dry land area above and landward of the Ordinary High Water Mark. A general term to mean high land far from the coast and in the interior of the country. |
| **Upper Galveston Bay Watershed** | Galveston Bay actually has two large "upper watersheds," consisting of 2,828 square miles upstream of Lake Houston on the San Jacinto River and 26,000 square miles upstream of Lake Livingston on the Trinity River. |
| **Urodeles** | Order of amphibians including salamanders and newts. |

# V

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| **Valued environmental attributes/components (VECs)** | Those aspects of ecosystems, human health, and environmental welfare considered to be important and potentially at risk from human activity or natural hazards. |
| **Viewsheds** | Area of land or water visible to human eye from a fixed vantage point. |
| **Visual resources** | The visible physical features of a landscape (topography, water, vegetation, animals, structures, and other features) that constitute the scenery of an area. |
| **Volatile organic compound (VOC)** | Any reactive, organic compound which is emitted to the atmosphere as a vapor. The definition does not include methane. |
| **Vulnerability** | The likelihood of being damaged by external influences. Vulnerability implies sensitivity of a system plus the risk of a damaging influence occurring. |

# W

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| **Wastewater collection system** | The system of pipes and pumping stations (lift stations) used to collect and carry wastewater from individual sources such as a wastewater treatment facility. |
| **Water column** | An imaginary vertical column of water used as a control volume for computational purposes. |
| **Water exchange** | The transport of waters into and out of the bay; exchange of waters of the bay with that of the Gulf of Mexico and tributaries through the forces of tide and freshwater inflow. |
| **Water Right** | A right acquired under the laws of the state to impound, divert, or use state water. |
| **Watershed** | An area from which water drains into a river, river system, or other body of water. |
| **Waters of the United States** | As defined by the Clean Water Act, waters of the United States includes waters subject to the ebb and flow of the tide; the territorial seas; interstate waters; waters that were previously used, currently used, or may be used for interstate or foreign commerce; waters for the which the use, degradation or destruction could affect intersate or foreign commerce; impoundments and tributaries of defined waters of the United States, and wetlands adjacent to defined waters of the United States. |
| **Weathering** | The destruction process by which atmospheric or biologic agents change rocks, causing physical disintegration and chemical decomposition. |

**Wetland**

Land or areas with standing water of a high water table either permanently or for some significant period each year. Wetlands typically include swamps, marshes, bogs and similar areas with water-loving vegetation that grows in or around water.

# Z

**Zebra mussel risk assessment**

Qualitative and quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence of zebra mussel species.

**Zooplankton**

Microscopic aquatic animals that are suspended in and move within the water column; dependent on phytoplankton as a food source.

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2012

US Army Corps
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Galveston District

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